Validation of different surface flux products using characteristics of probability distributions of surface fluxes (TIE-OHF project)

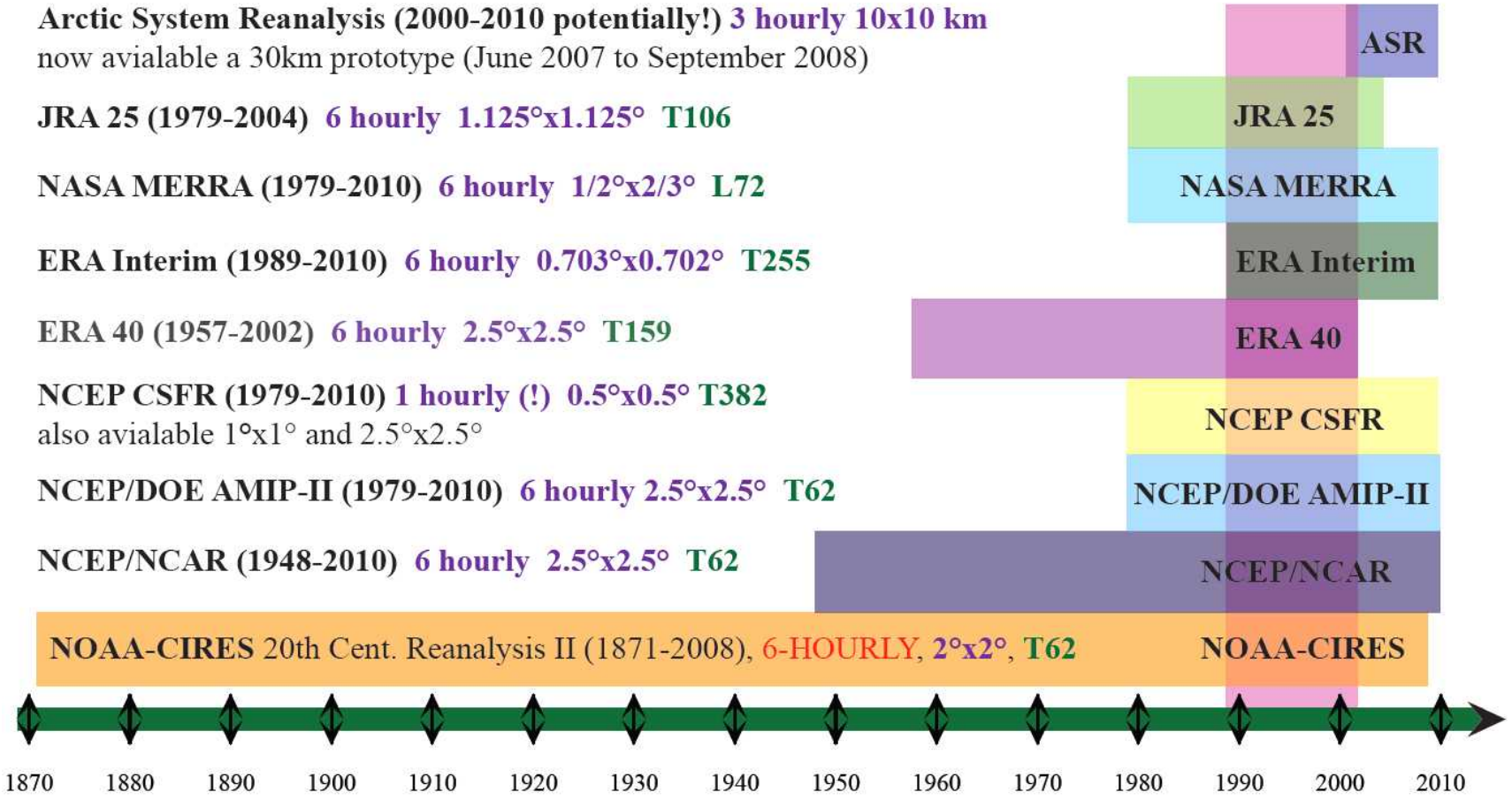
Sergey Gulev, P.P.Shirshov Institute of Oceanology, RAS (IORAS)

Outline

- Turbulent fluxes in atmospheric reanalyses and the concept of intercomparison – PDFs of turbulent fluxes
- Comparison of modern era reanalyses – means, parameters of PDFs, extreme fluxes vs mean fluxes
- Flux output and recomputed fluxes – does it matter?
- Fluxes from climate models vs reanalyses
- Conclusions and outlook

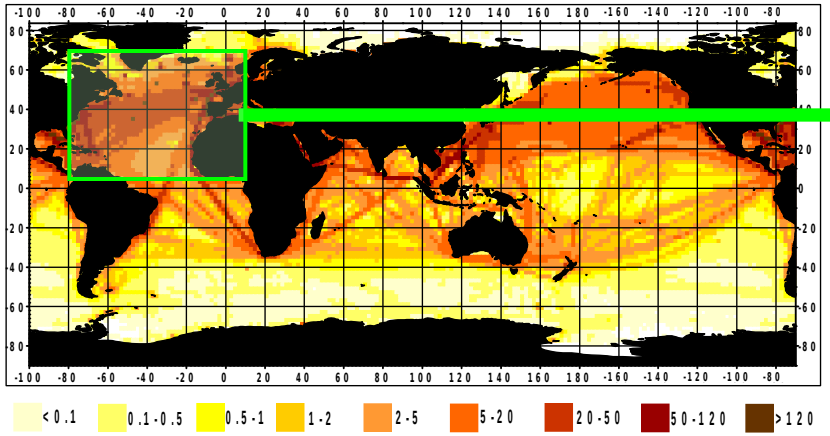
Products operating

Fluxes from reanalyses, NWP and climate models (diagnosed by reanalyses systems and recomputed using bulk formulae

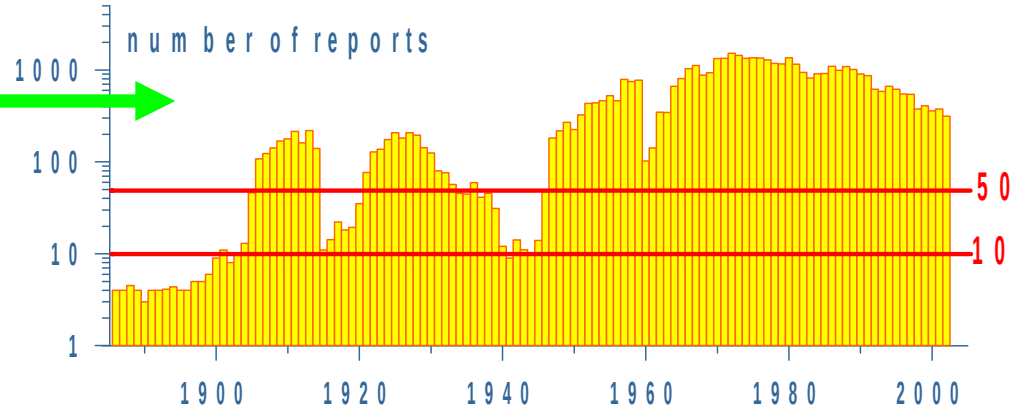


Products operating

VOS (Voluntary Observing Ship) – based fluxes: NOC (1979-onwards), IORAS (NA, 1880-)



Number of reports in VOS (ICOADS) in 2°×2° boxes per month (1948- onwards)



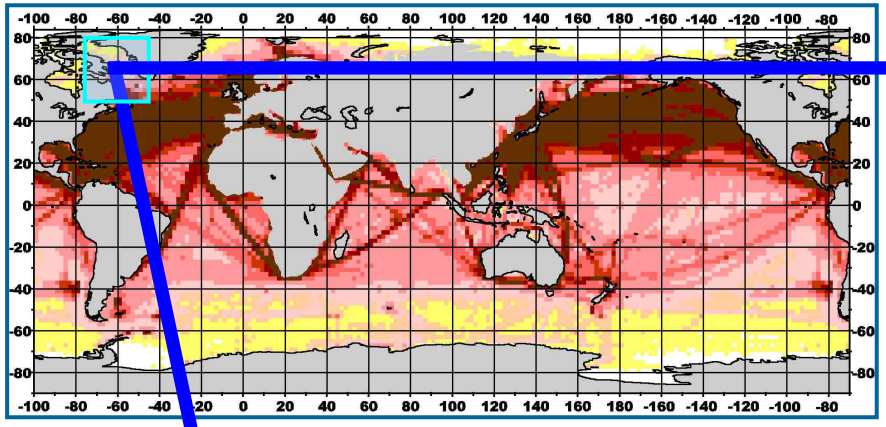
Time change of the number of VOS reports in 5°×5° cell in the NA

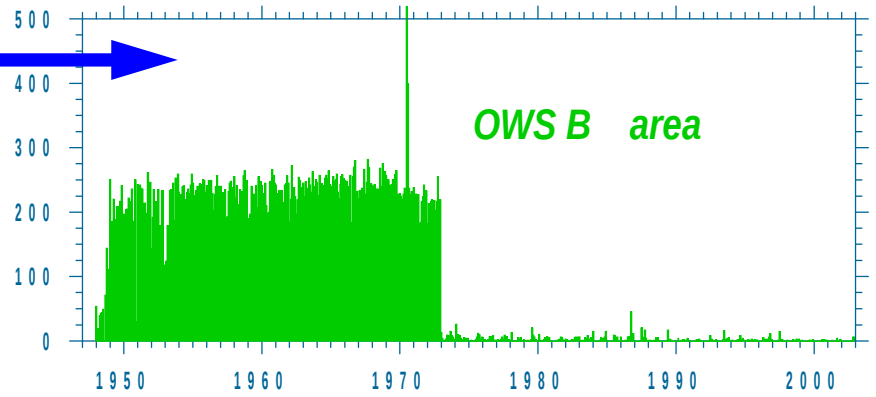
Project relevant techniques

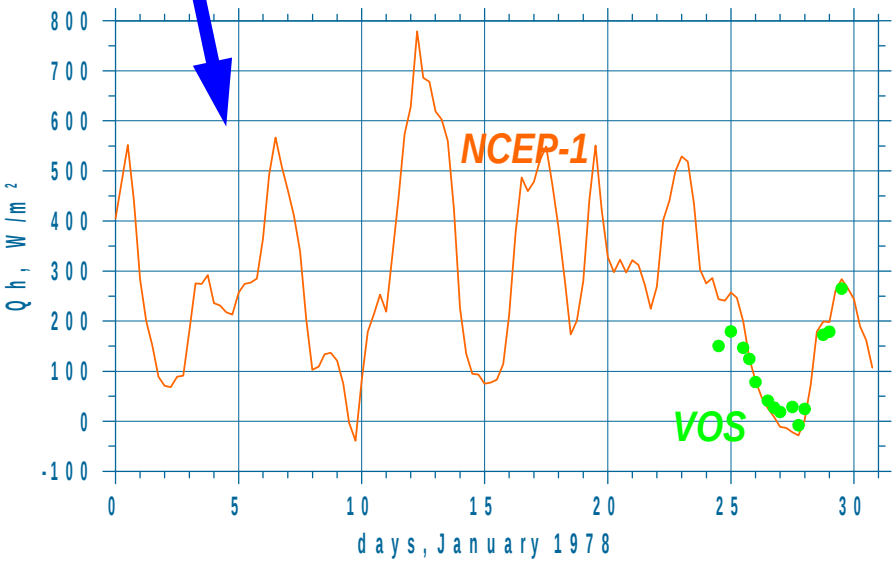
Estimation and minimization of sampling errors

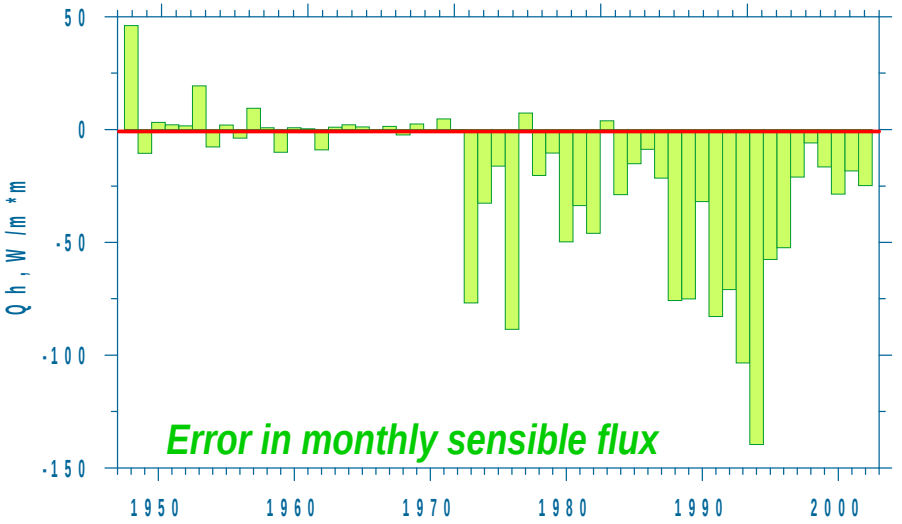
Reconstruction of locally and areal integrated turbulent fluxes

The nature of sampling bias in air-sea fluxes

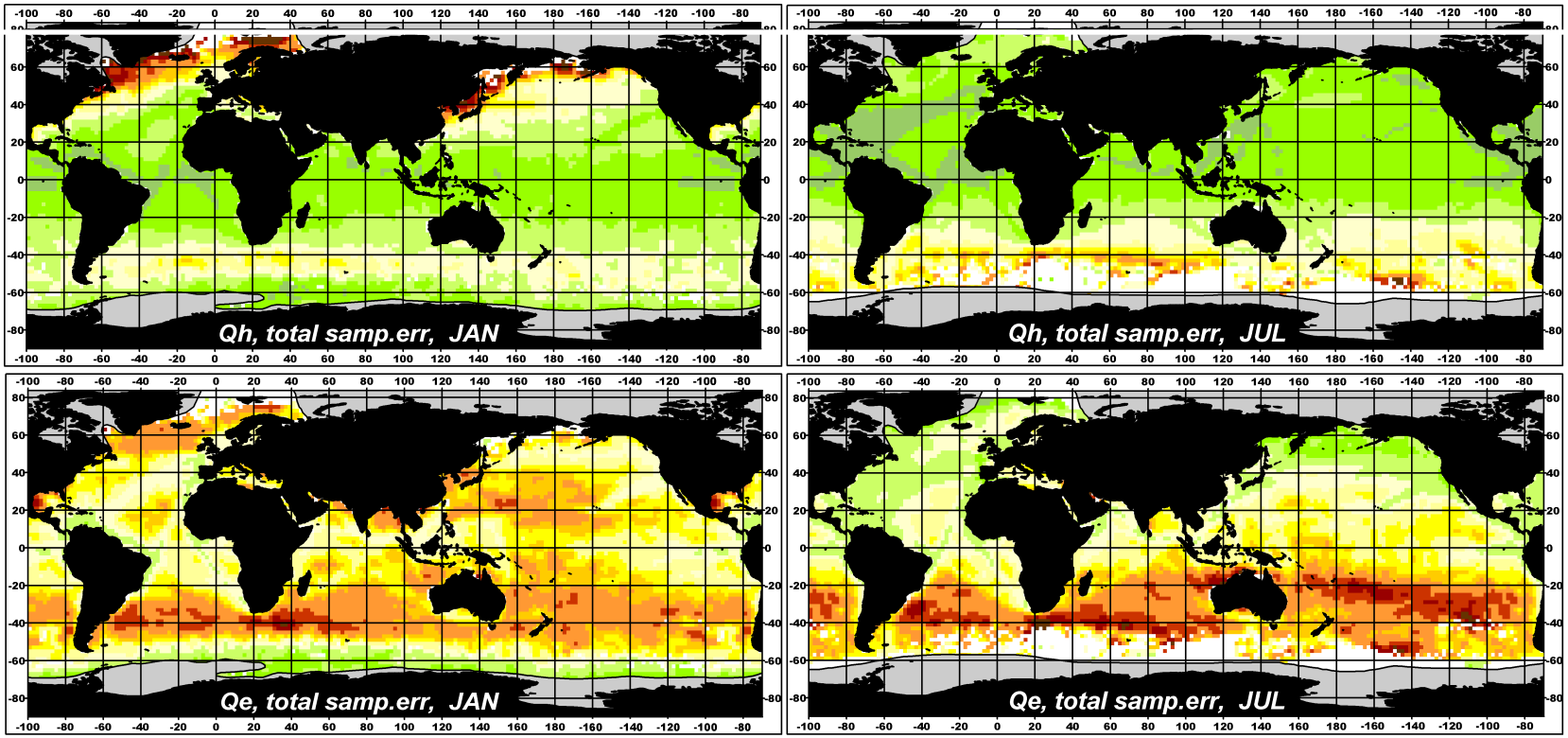


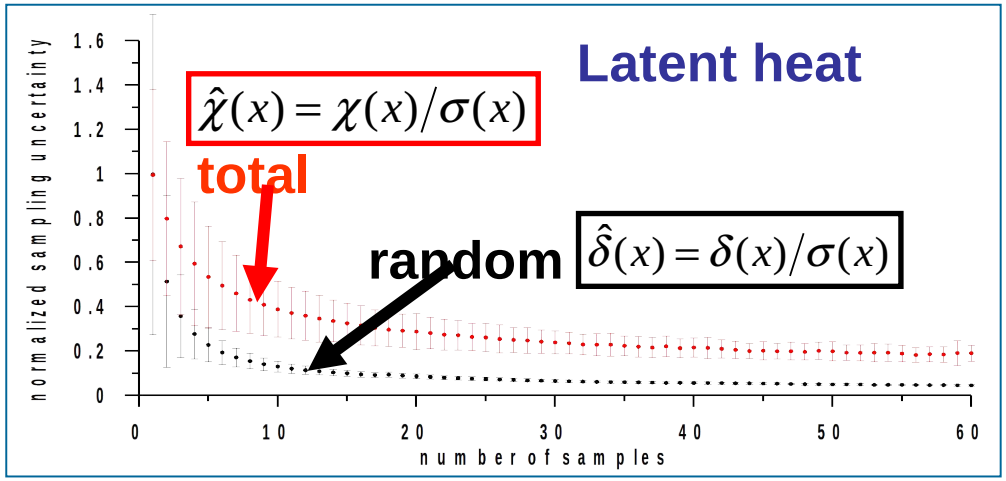






Magnitude of sampling uncertainty

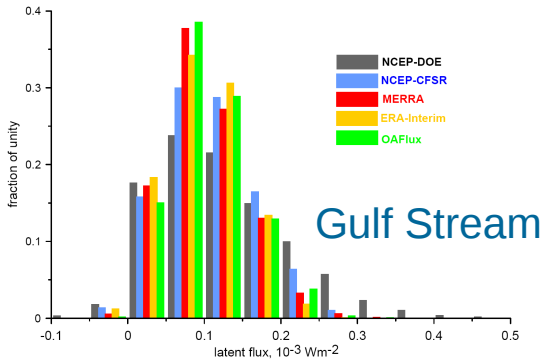


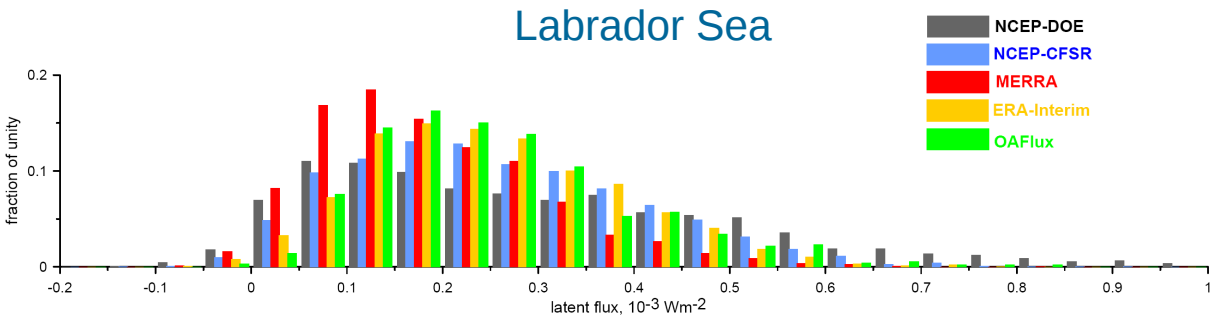


Minor effect of fair weather bias, the largest effect comes from the time grouping of observations

Gulev et al., 2007a,b

Concept of intercomparison: probability distributions

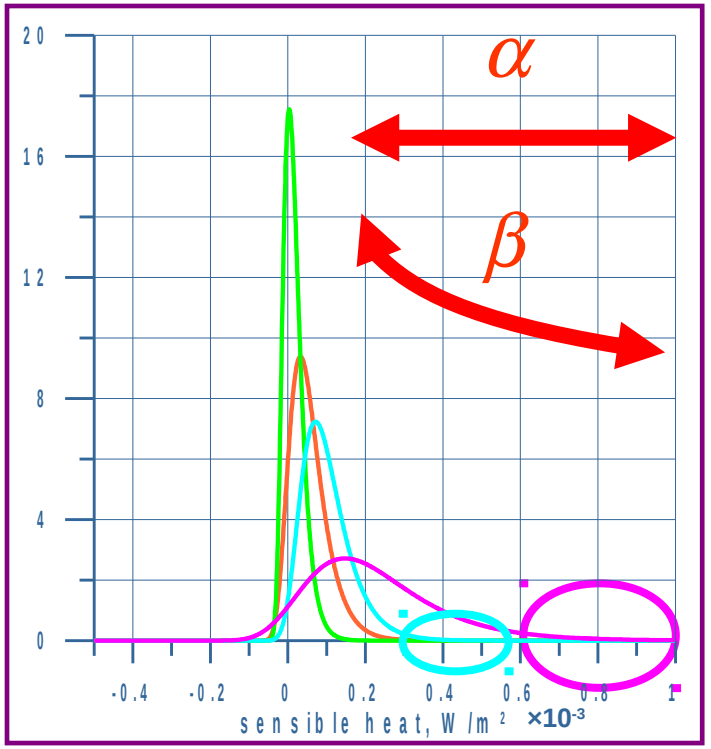




MFT distribution for turbulent fluxes – 1D case

$$P(x) = (\alpha \cdot \beta) \cdot e^{\beta x} \cdot e^{-\alpha \cdot e^{\beta x}}, \quad \alpha > 0, \beta > 0$$

$$\bar{x} = \frac{C + \ln \alpha}{-\beta}, \ \mathrm{var}\ x = \frac{\pi^2}{6\beta^2}$$



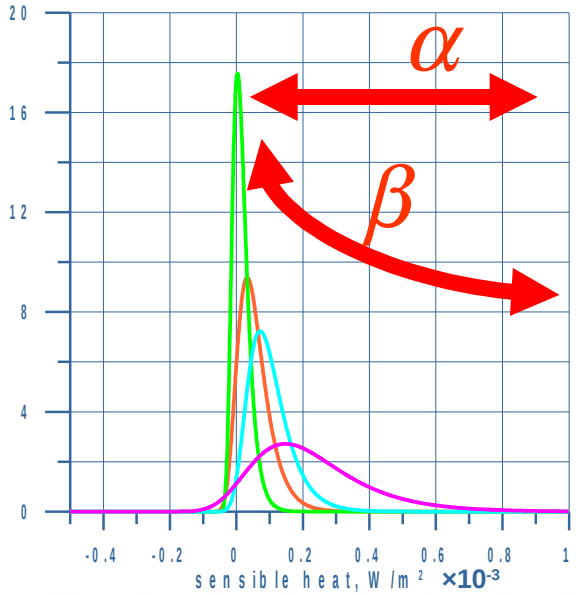
- Estimation of extreme fluxes
- Integrations of fluxes over space and time
- Minimization of sampling errors (long-term reconstructions)

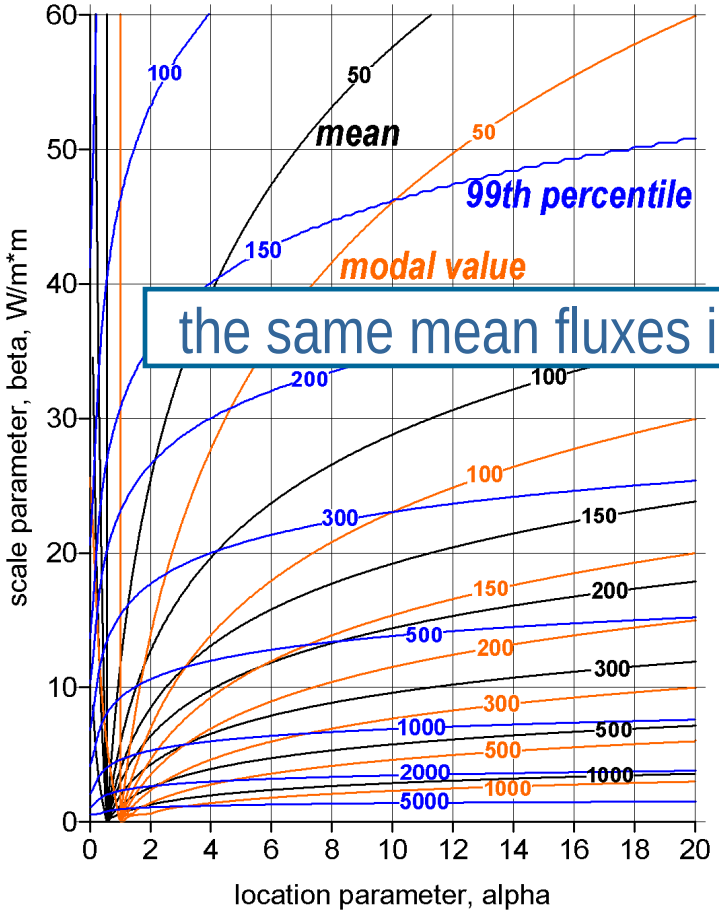
Modified FT-distribution

(Gulev and Belyaev, 2012, J. Climate)

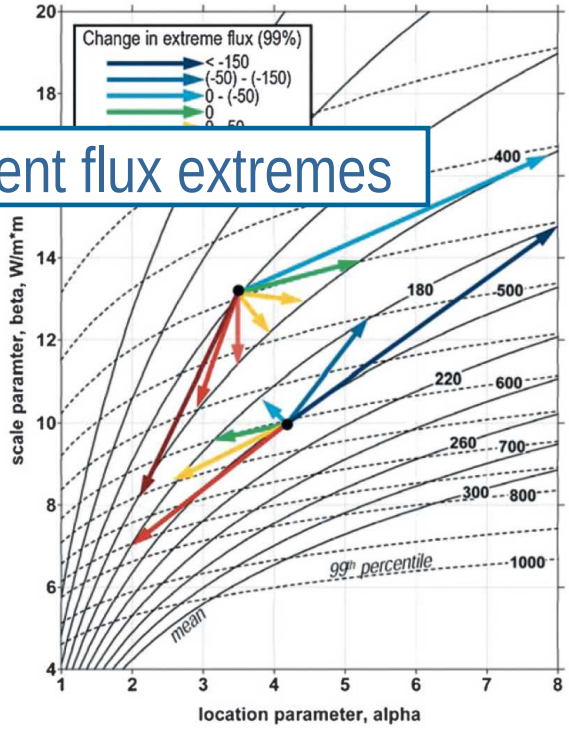
$$P(x) = (\alpha \cdot \beta) \cdot e^{\beta x} \cdot e^{-\alpha \cdot e^{\beta x}}, \alpha > 0, \beta > 0$$

$$\bar{x} = \left(C + \ln \alpha\right) / -\beta, \text{ var } x = \pi^2 / 6\beta^2$$

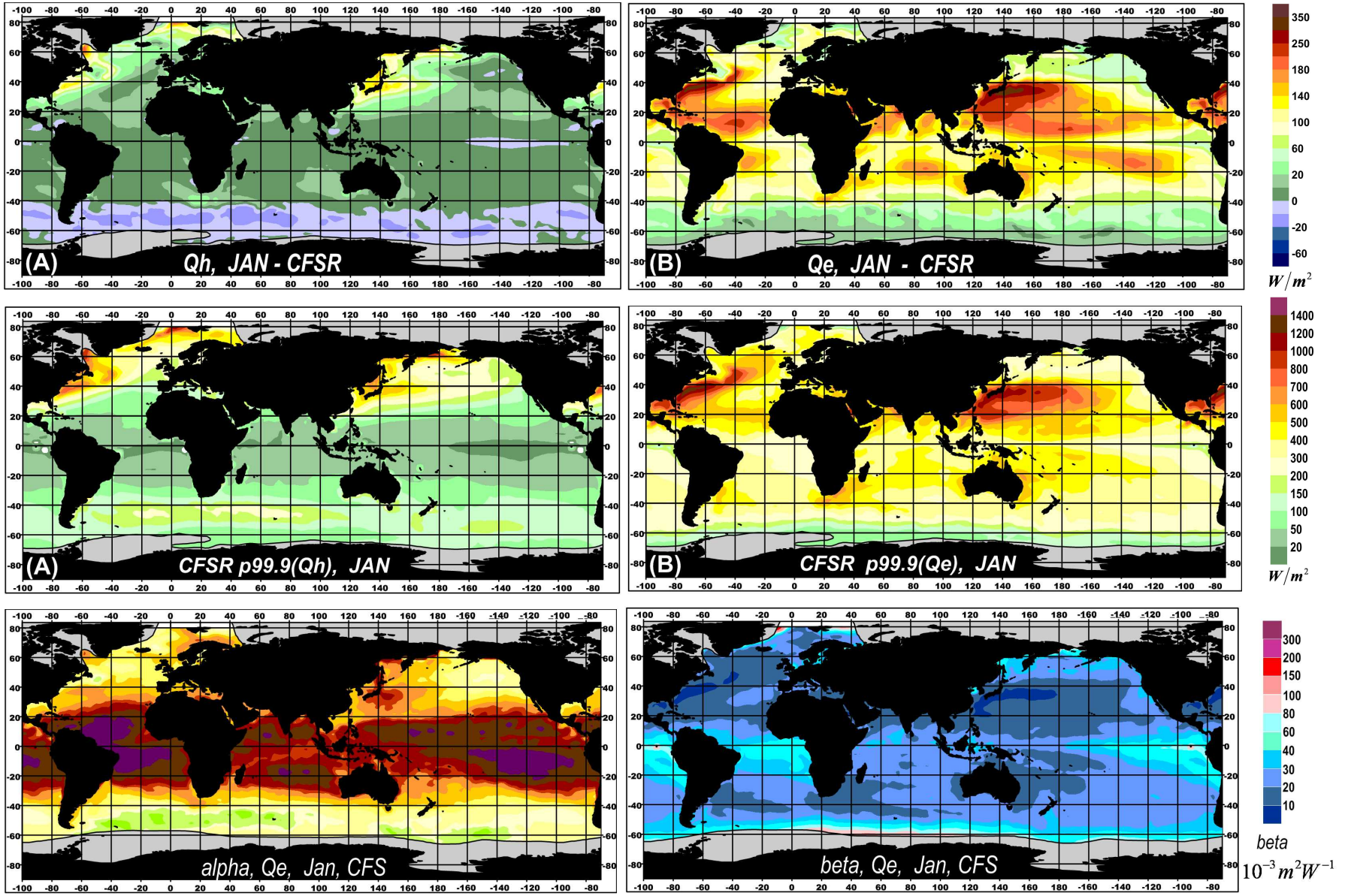




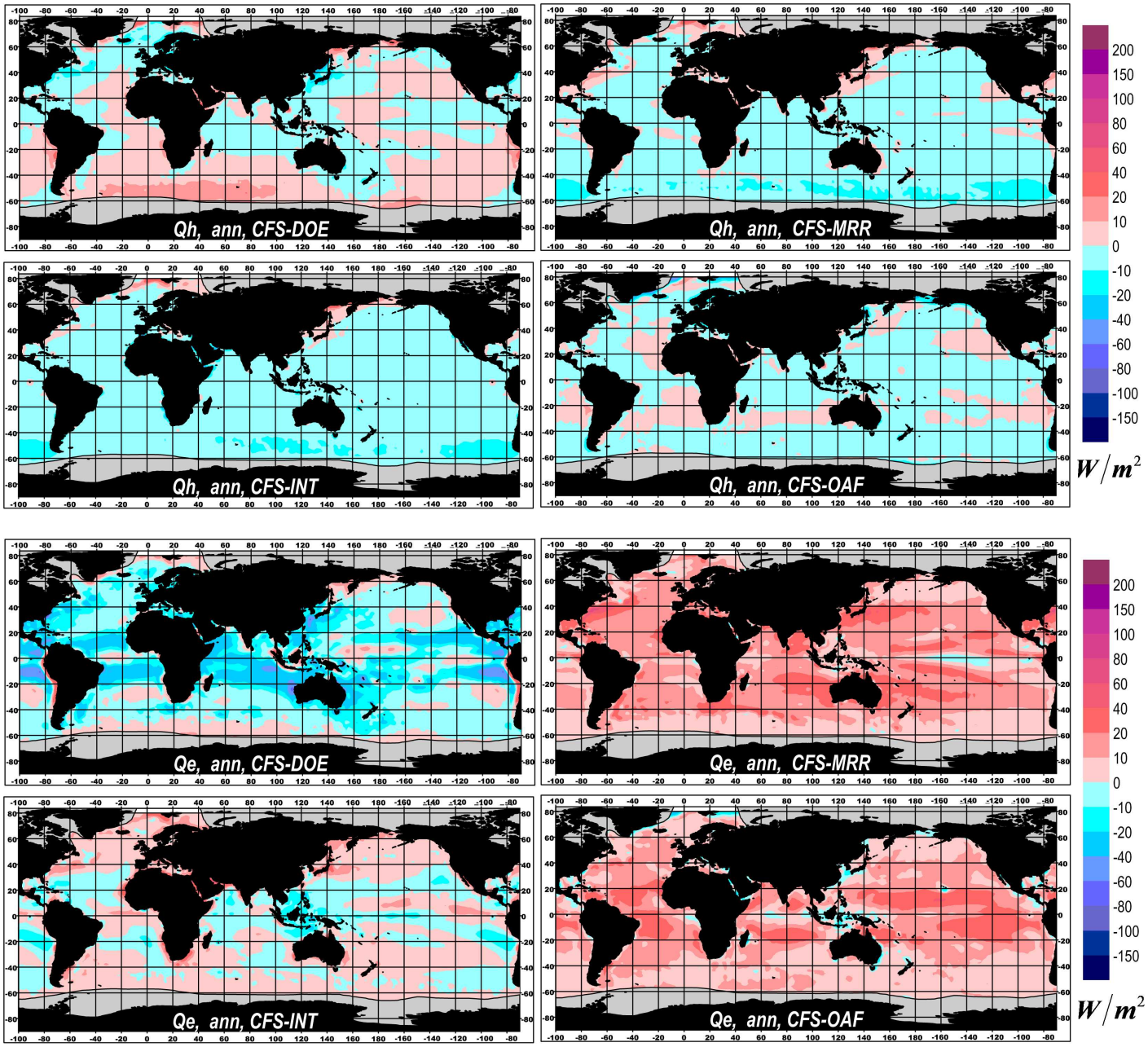
the same mean fluxes imply different flux extremes



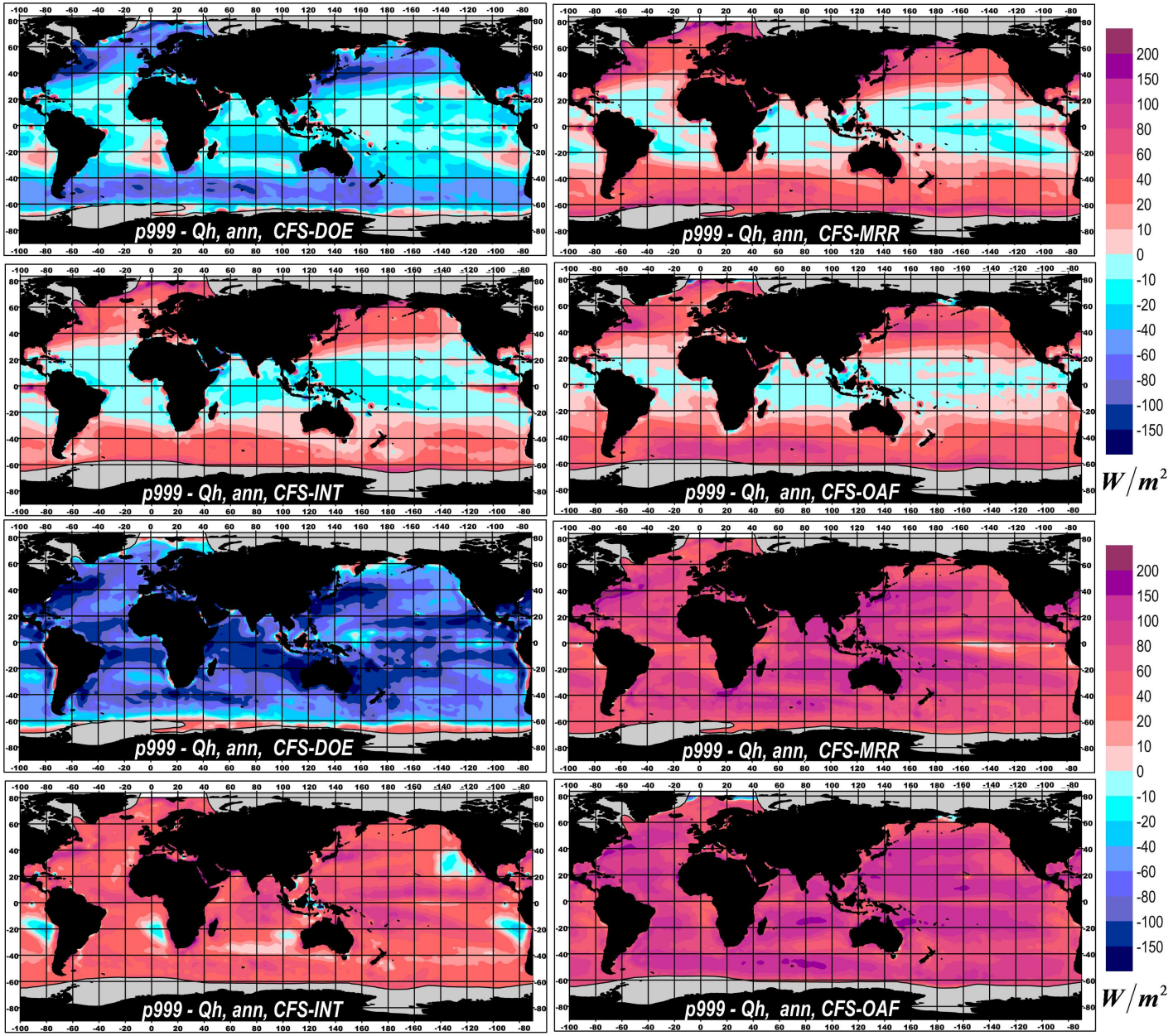
Flux climatologies for NCEP-CFSR



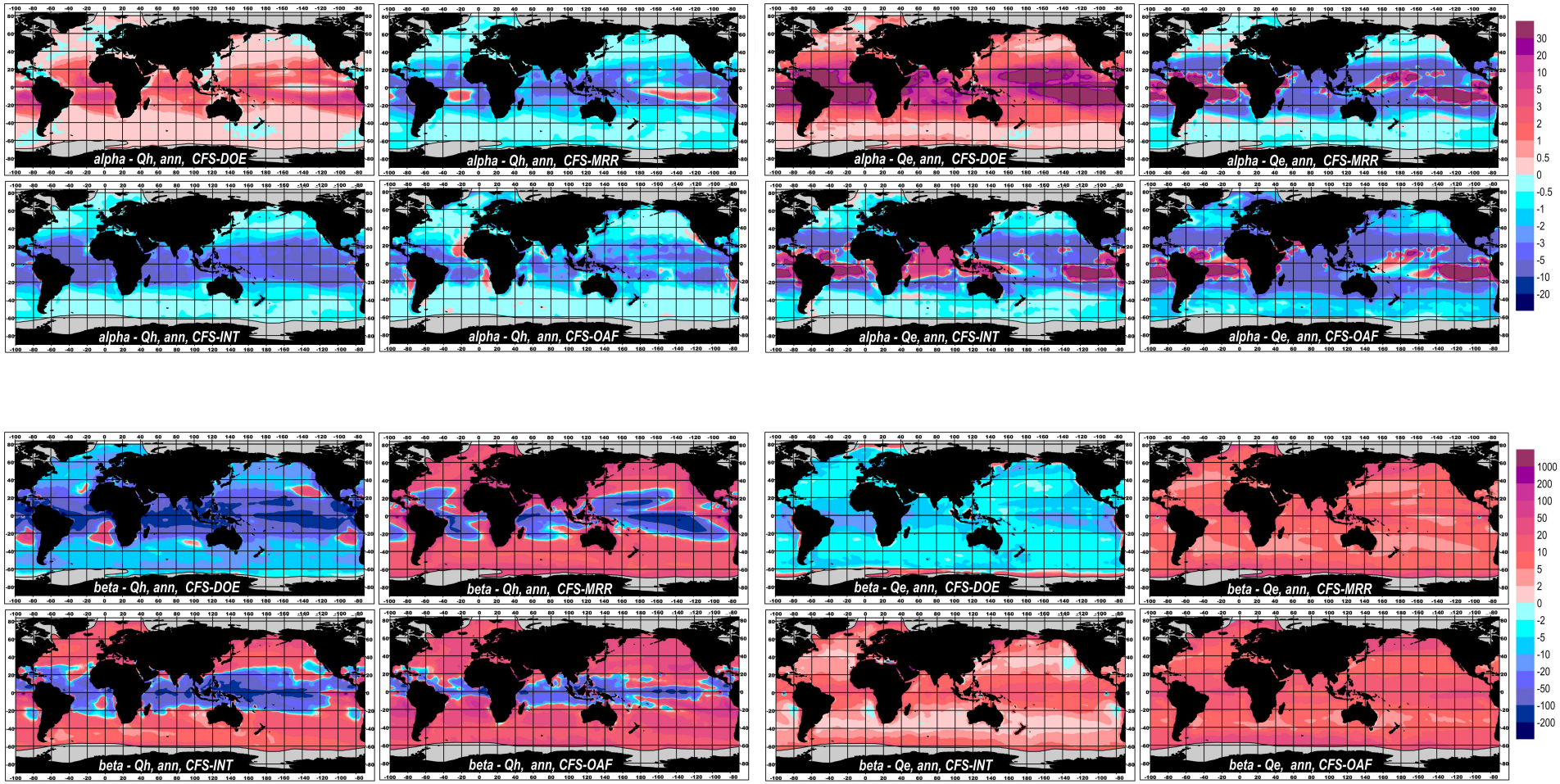
Mean fluxes: differences with CFSR



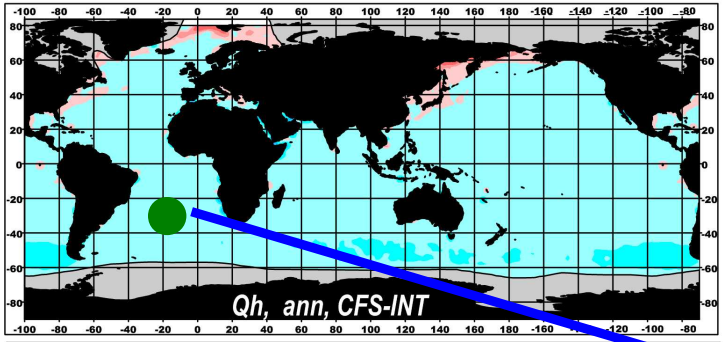
Extreme fluxes - differences with CFSR

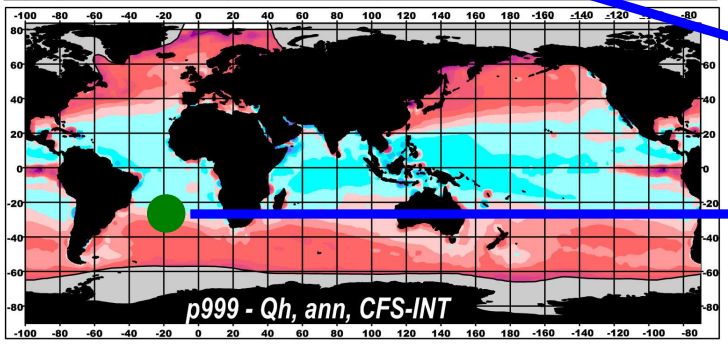


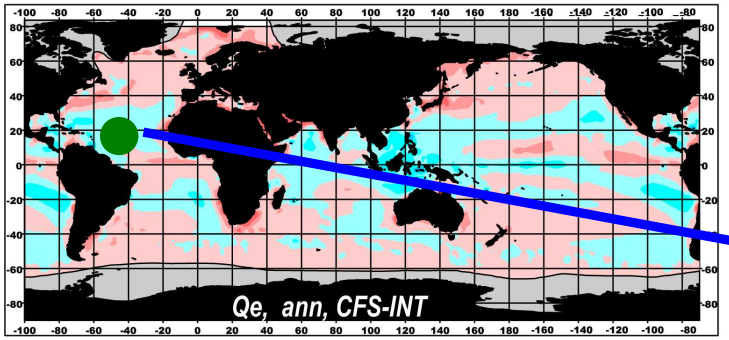
Shape (β) and location (α) parameters - differences with CFSR

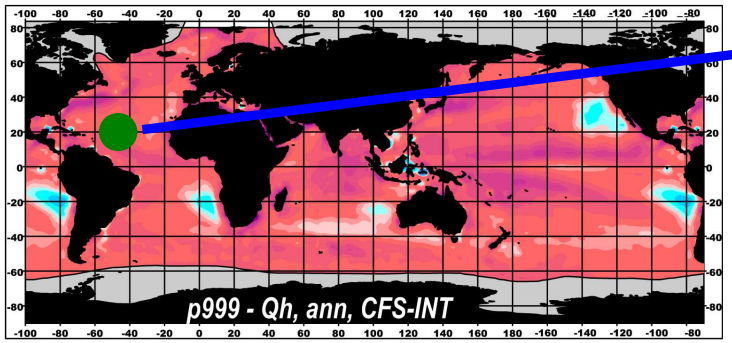


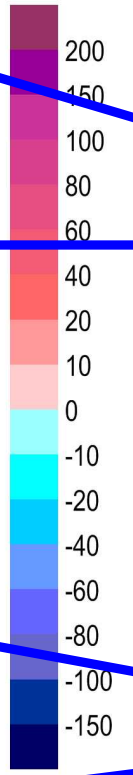
Differences in means ≠ differences in extremes

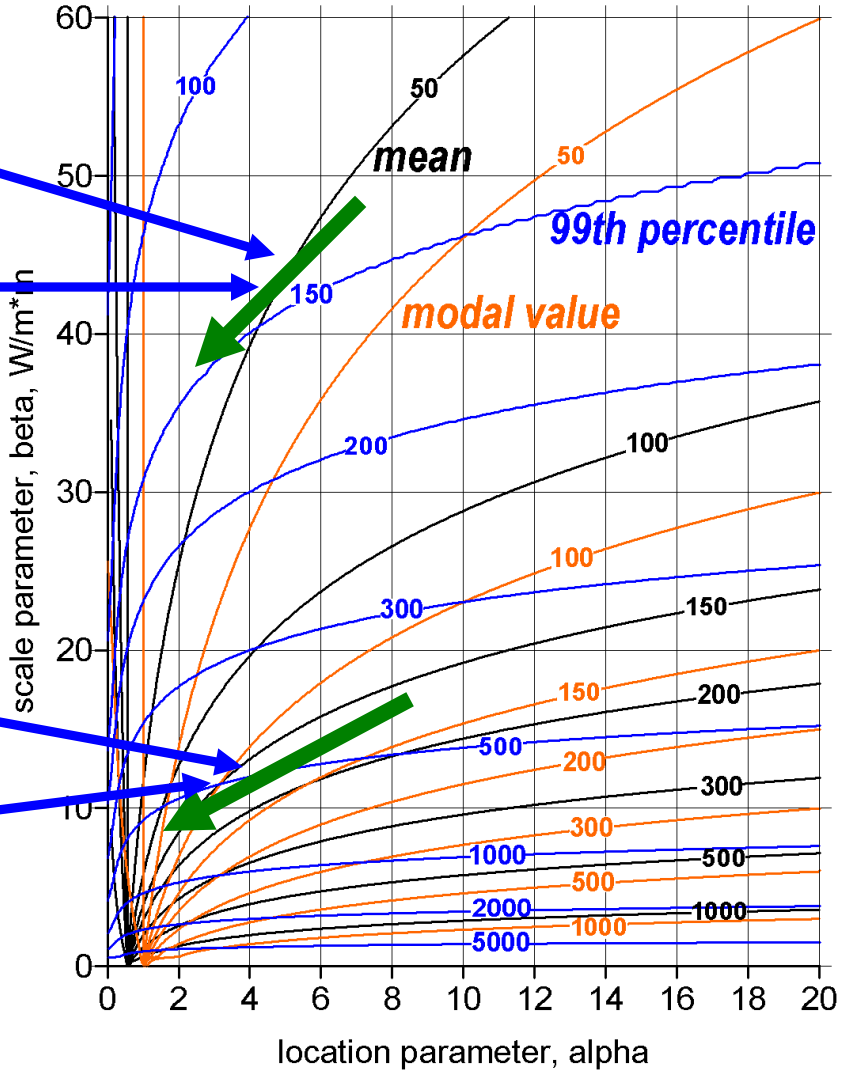




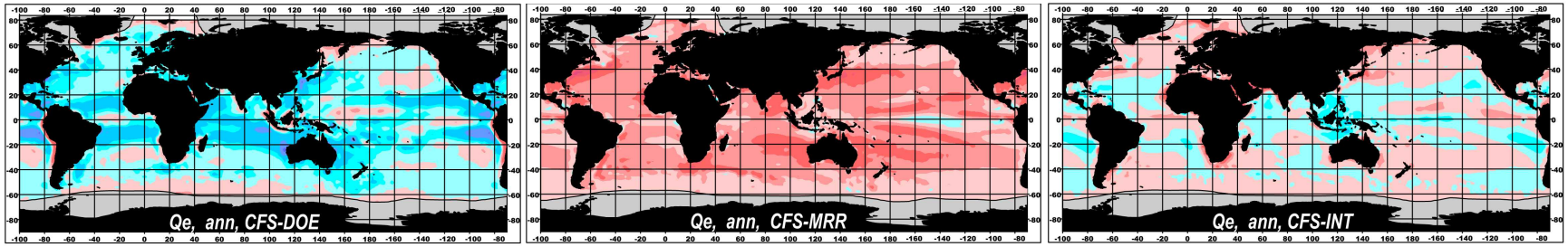




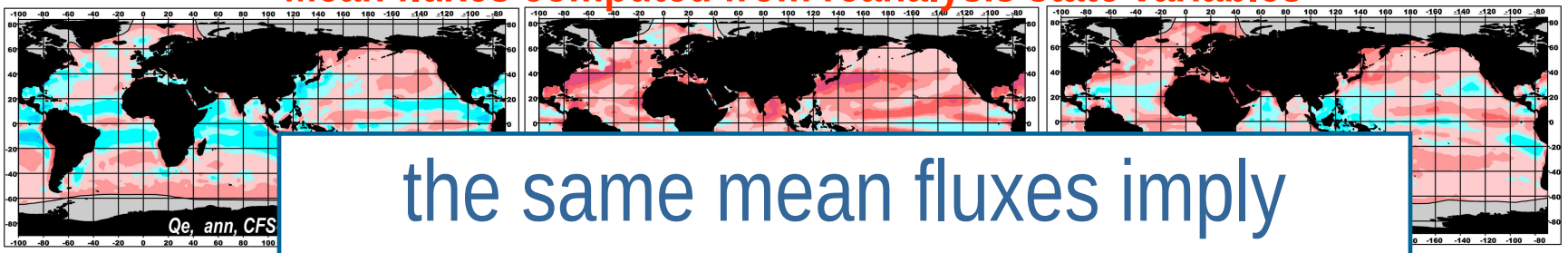




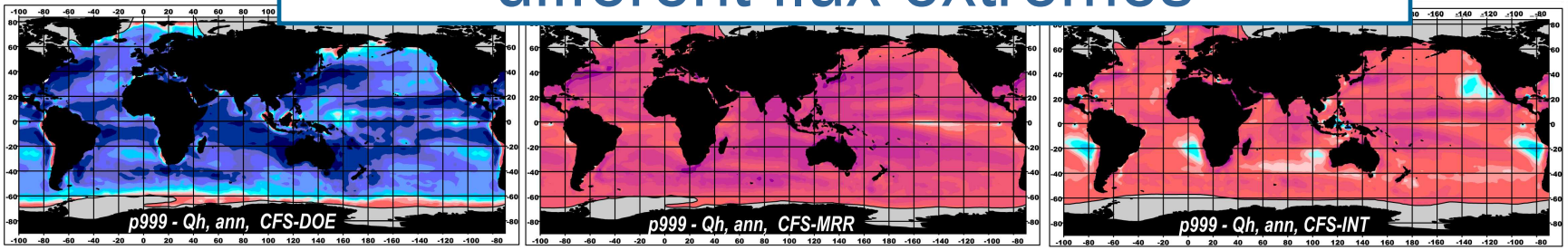
Mean fluxes as revealed by products



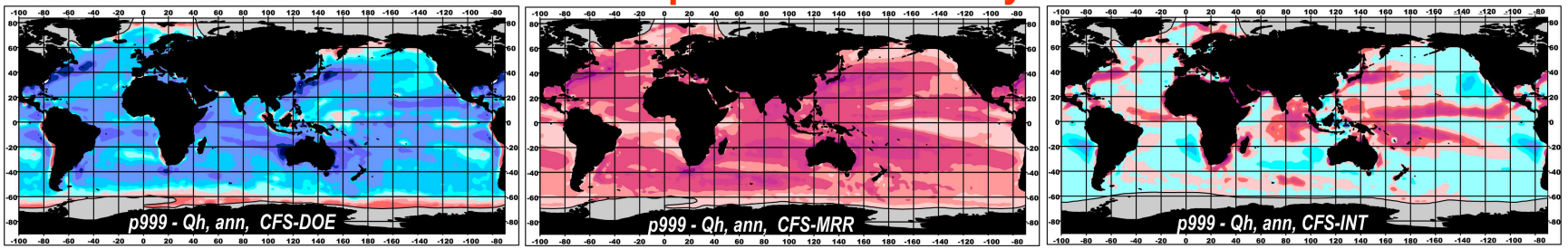
Mean fluxes computed from reanalysis state variables



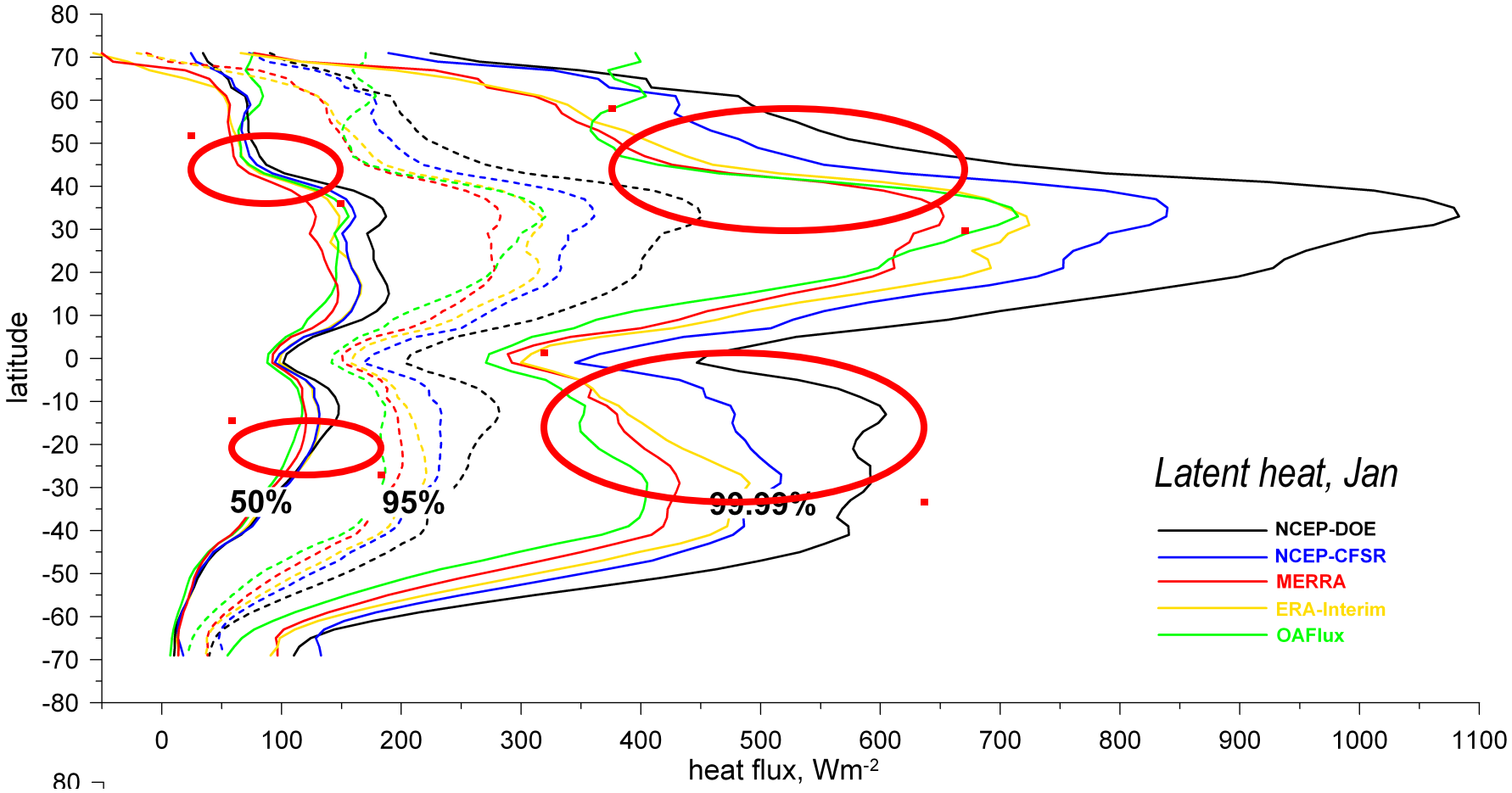
the same mean fluxes imply different flux extremes



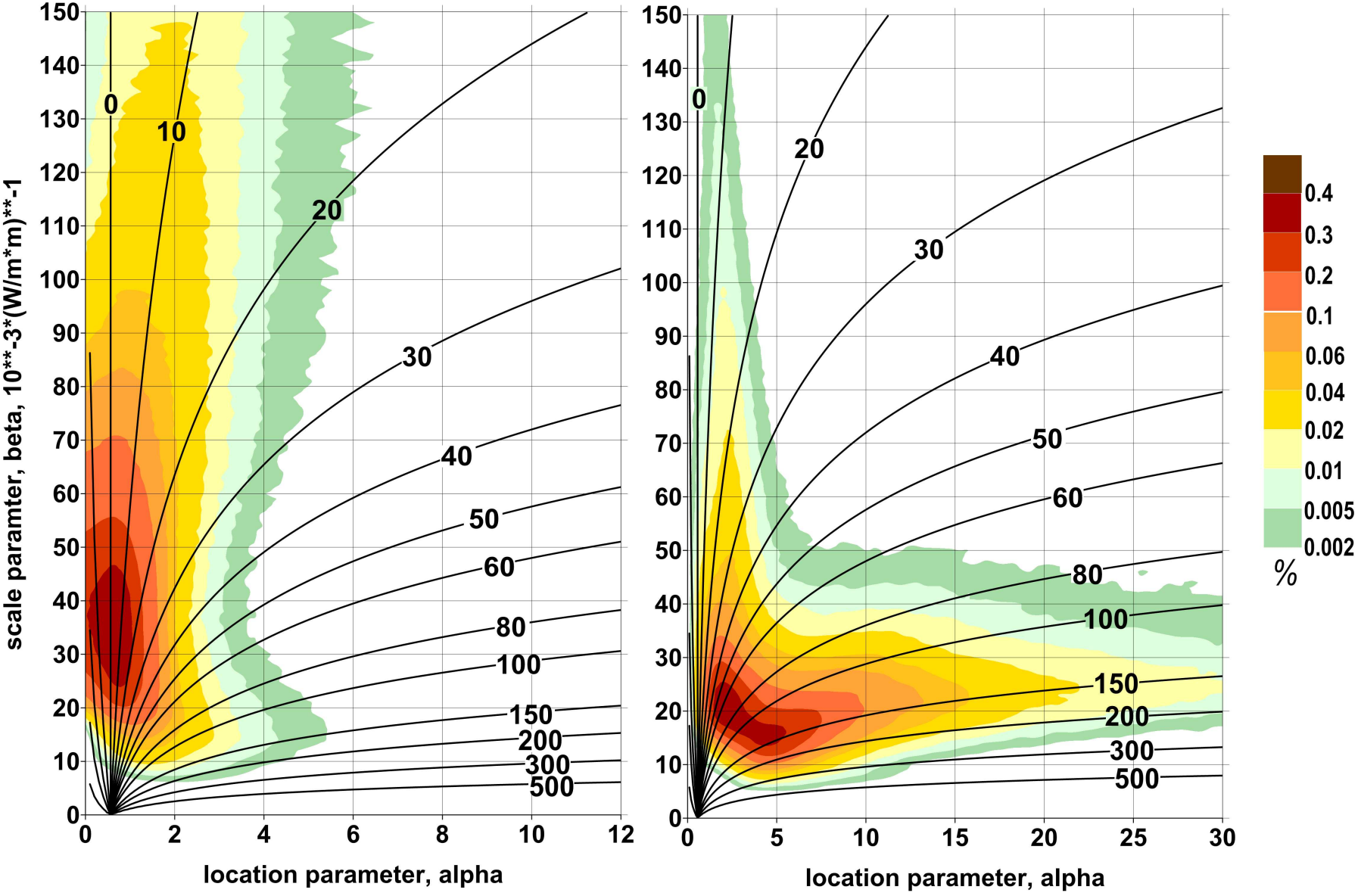
Extreme fluxes computed from reanalysis state variables



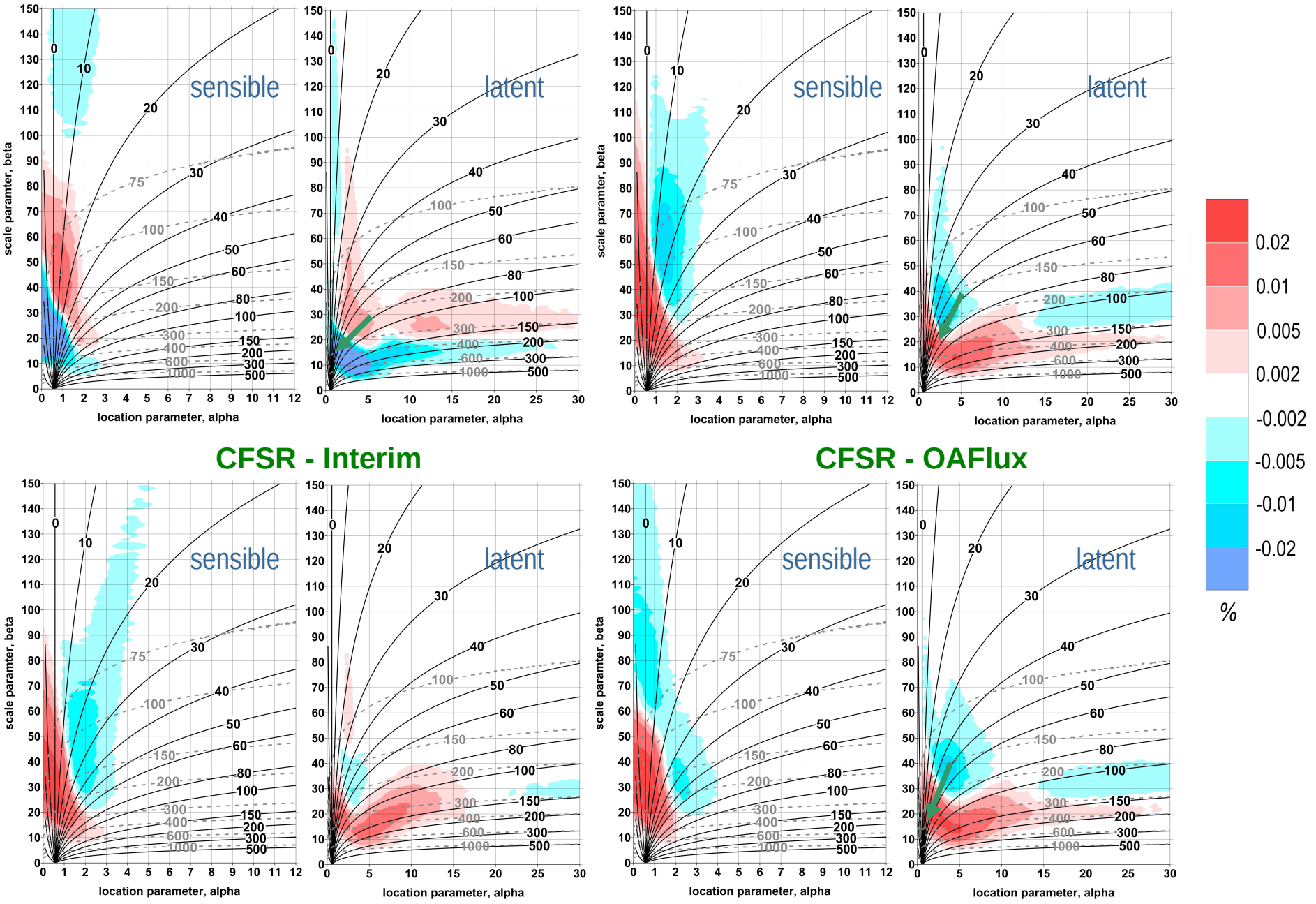
Zonally averaged latent heat flux percentiles



Integration of fluxes at α,β- diagram - NCEP-CFSR



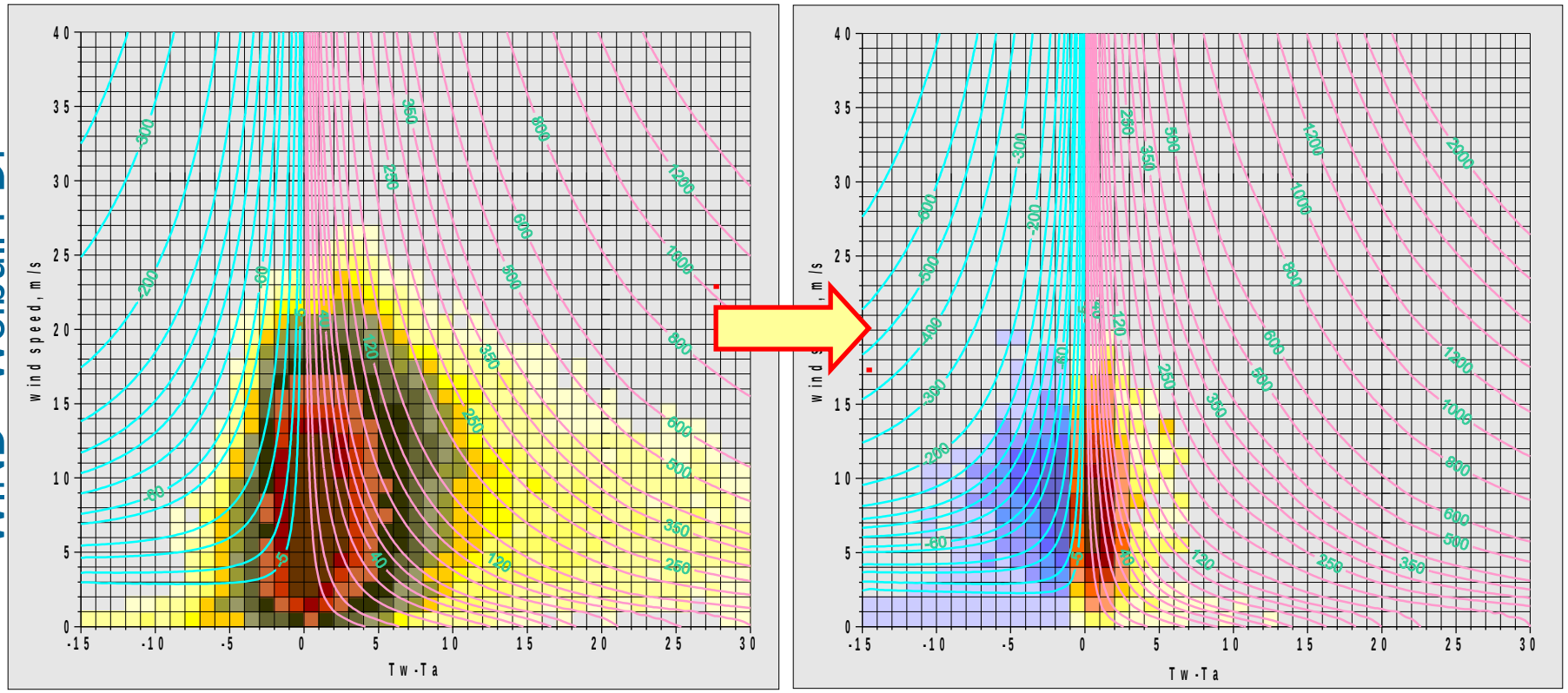
Difference at α,β- diagram vs NCEP-CFSR



MFT+Weibull distribution for turbulent fluxes – 2D case

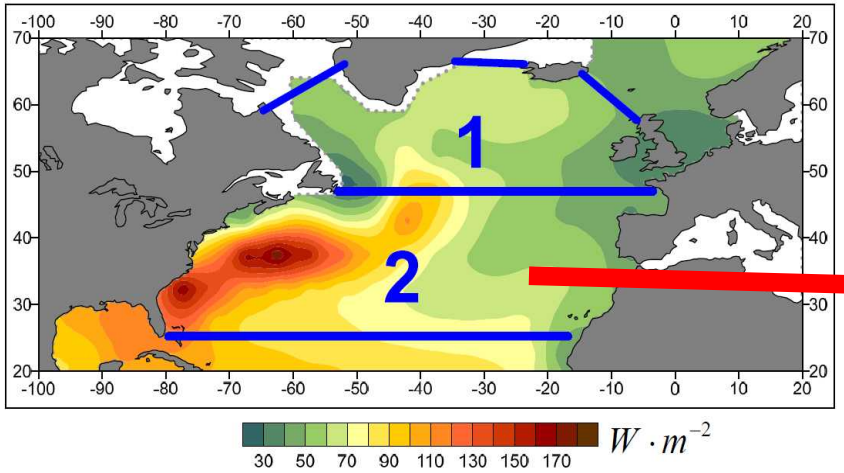
$$P(V \mid \delta T) \cdot P(\delta T) = \frac{\alpha_V}{\beta_V}\left(\frac{V}{\beta_V}\right)^{\alpha_V - 1} \cdot e^{-\left(\frac{V}{\beta_V}\right)^{\alpha_V}} \cdot (\alpha_T \cdot \beta_T) \cdot e^{\beta_T \delta T} \cdot e^{-\alpha_T \cdot e^{\beta_T \delta T}}$$

WIND - Weibull PDF

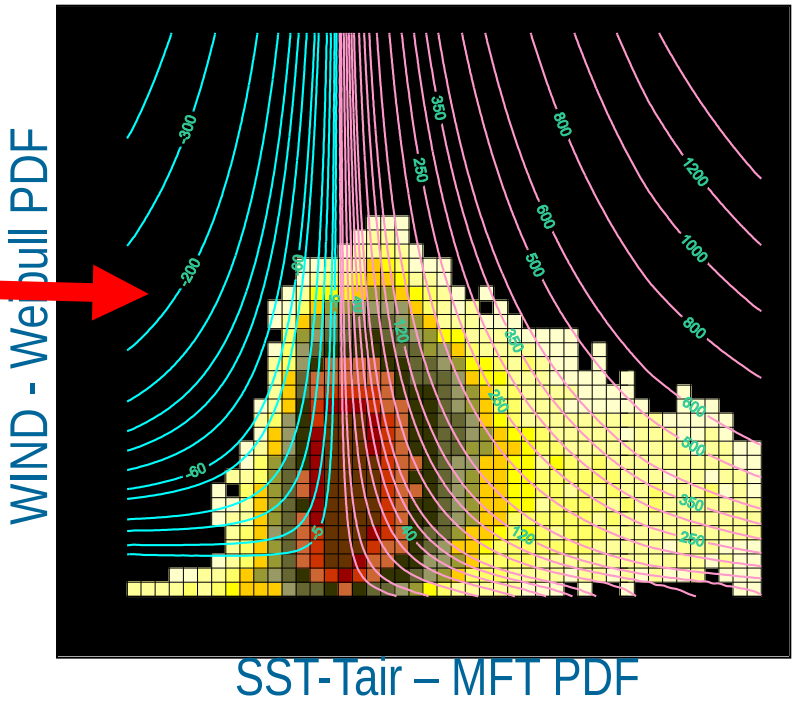


SST-T_{air} –MFT-PDF

Regionally integrated fluxes



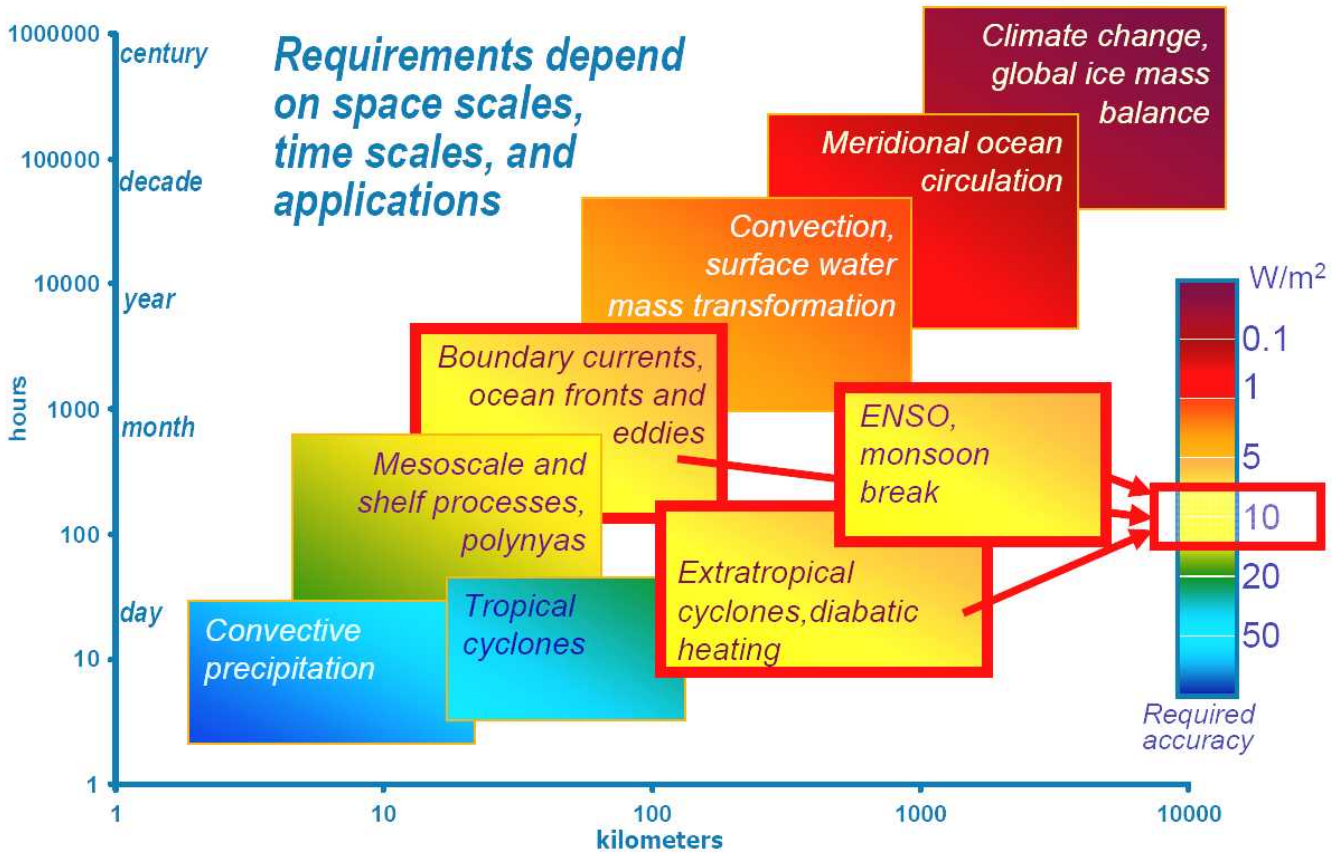
$$Q_\Sigma = \int_t dt \int_S Q dS = \int_V dV \int_{\delta T} Q d(\delta T)$$

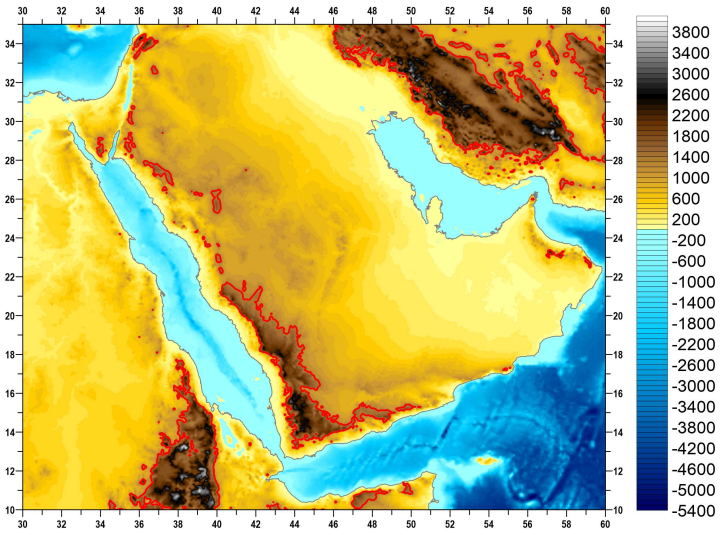


Sampling uncertainty of the regionally integrated surface flux	1	2	Global	SO
Real VOS sampling	0.35*10^{14} W	0.57*10^{14} W	1.74*10^{14} W	0.39*10^{14} W
1-D reconstruction (MFT)	0.22*10^{14} W	0.43*10^{14} W	1.43*10^{14} W	0.30*10^{14} W
2-D reconstruction (W+MFT)	0.11*10^{14} W	0.37*10^{14} W	1.25*10^{14} W	0.26*10^{14} W

Contribution to TIE-OHF

Requirements – quantification of required accuracy (fetishism of 10 W/m^2)




30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
34 32 30 28 26 24 22 20 18 16 14 12 10
3800
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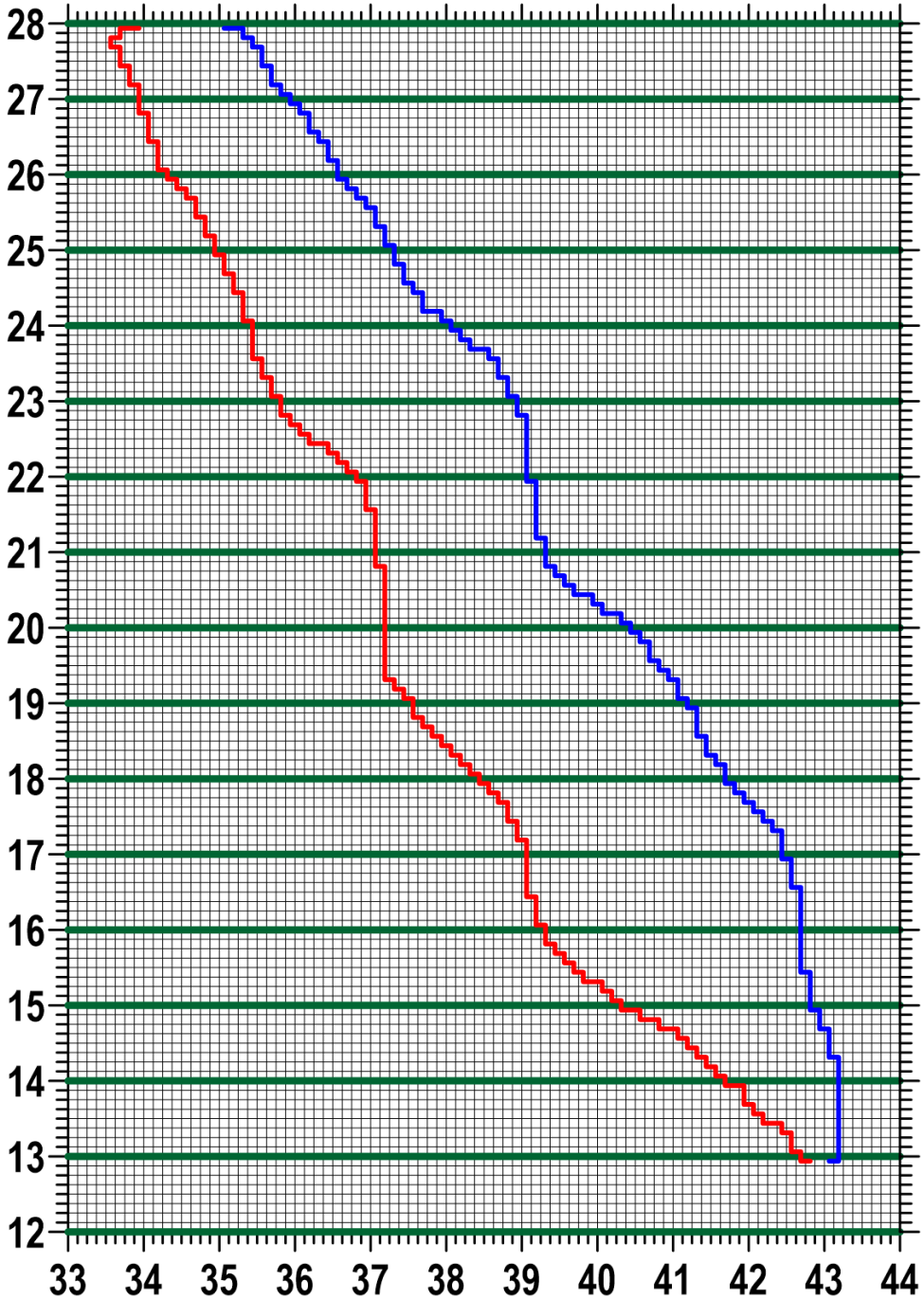
-5400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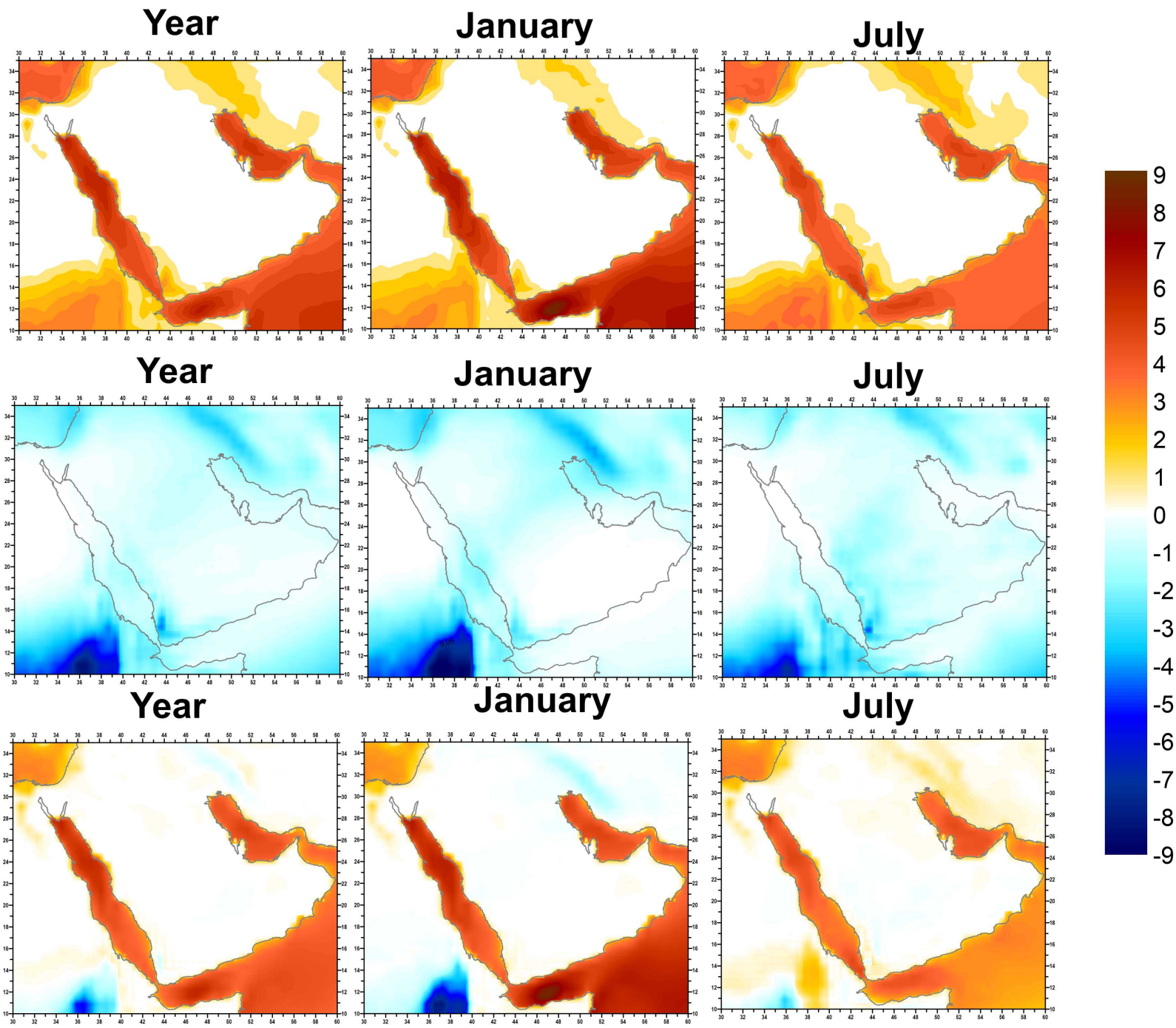
Year
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July
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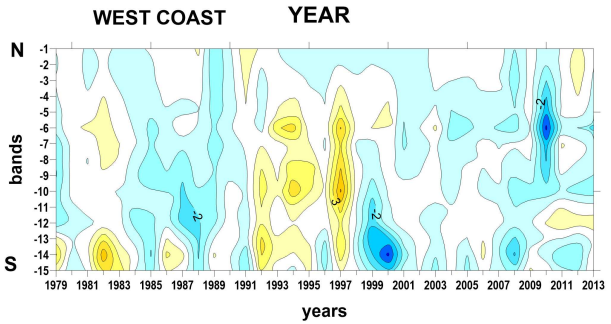
WEST COAST
YEAR
N
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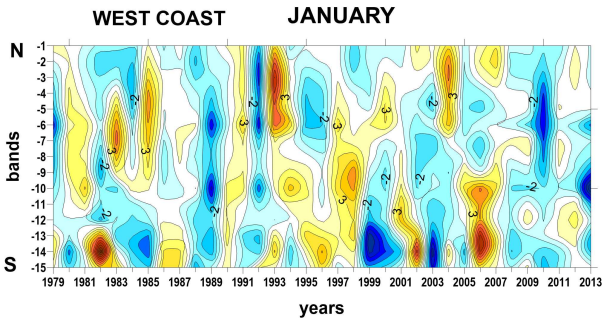
years


WEST COAST
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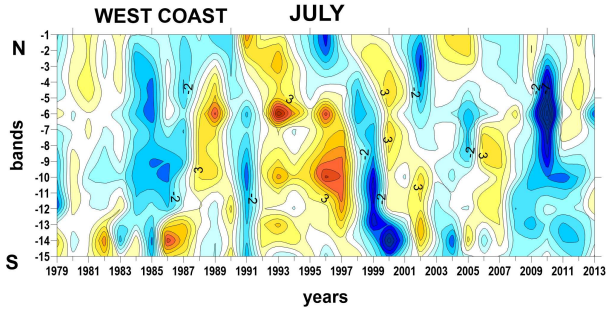
WEST COAST
JULY
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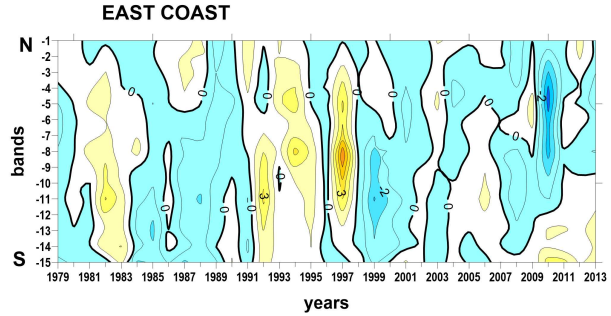
bands
years


EAST COAST
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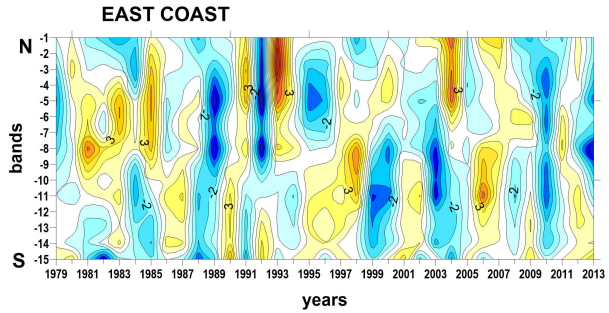
EAST COAST
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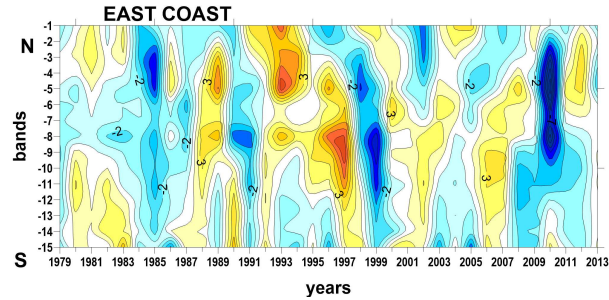
EAST COAST
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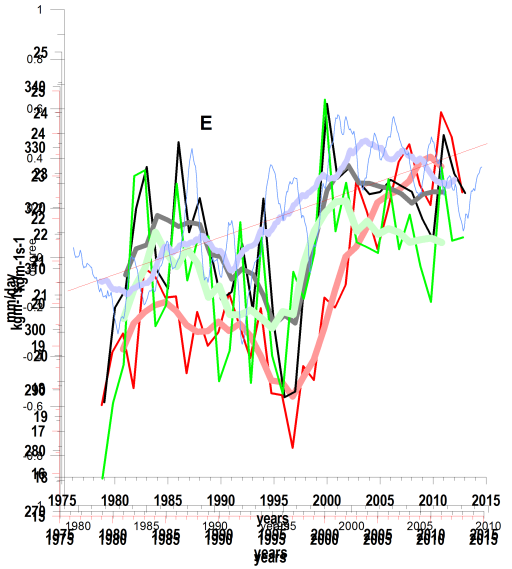
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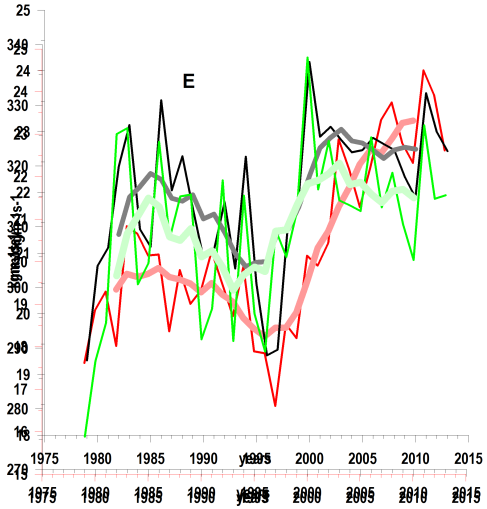
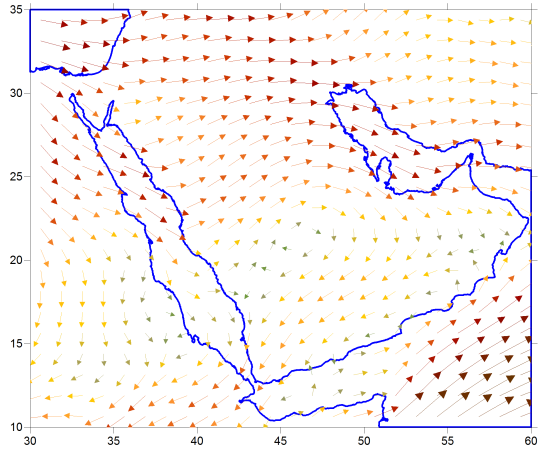
years

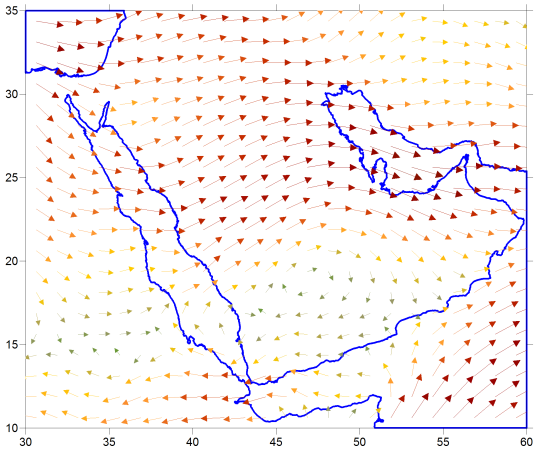

E
years

FLUXES

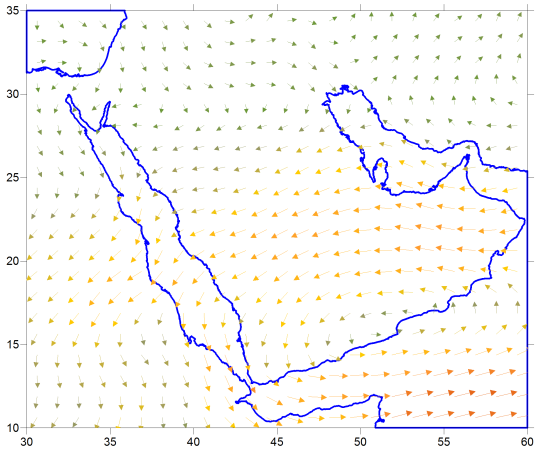
2011



1997

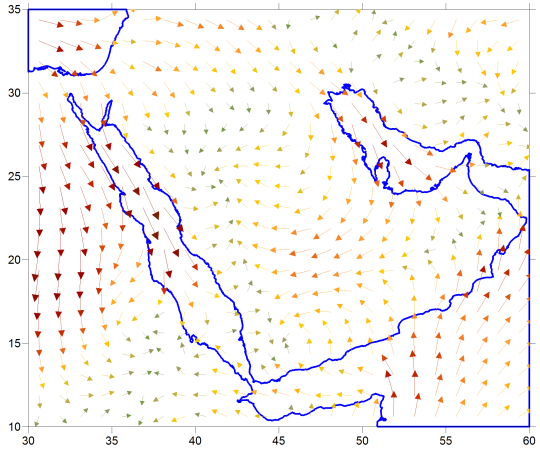


2011 minus 1997

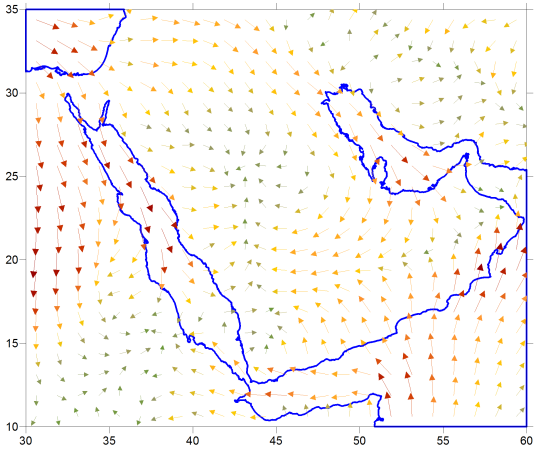


WIND

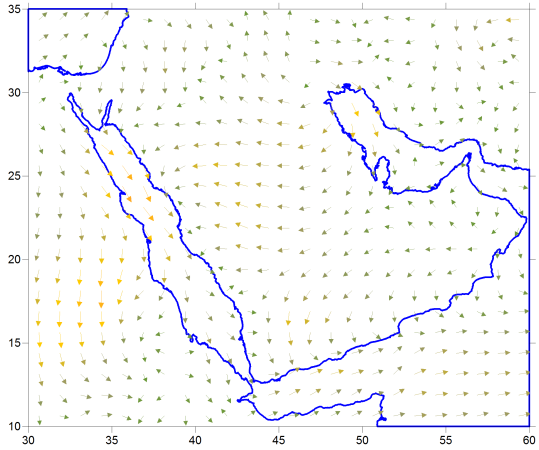
2011



1997



2011 minus 1997



Contribution to TIE-OHF

Task 3 – product generation, intercomparison and uncertainties

Analysis of global and regional PDFs and their parameters in generated products, evaluation of different parameterizations/algorithms with respect to their impact on distributions and extremes (sensitivity studies)

Intercomparison of generated products to reanalyses and VOS, including ASR

Derivation of sampling errors in generated products

Potentially – minimization of sampling errors using censored sampling theory (comment – I do not anticipate that the sampling error will be large, however it can grow for finer resolution, thus we can get guidance on the most relevant resolution of generated flux products)

Thing to discuss – we can also perform stochastic modelling of developed products of individual parameters. This can produce surrogate ensemble estimates of the parameters (and fluxes afterwards, to be computed). Statistics of surrogate ensemble can be used to estimate uncertainties in replicating PDFs by the generated products

→ Another source of knowledge about the uncertainty

→ Analog of blending – maybe even algorithm for bending

Contribution to TIE-OHF

Task 3 – product generation, intercomparison and uncertainties

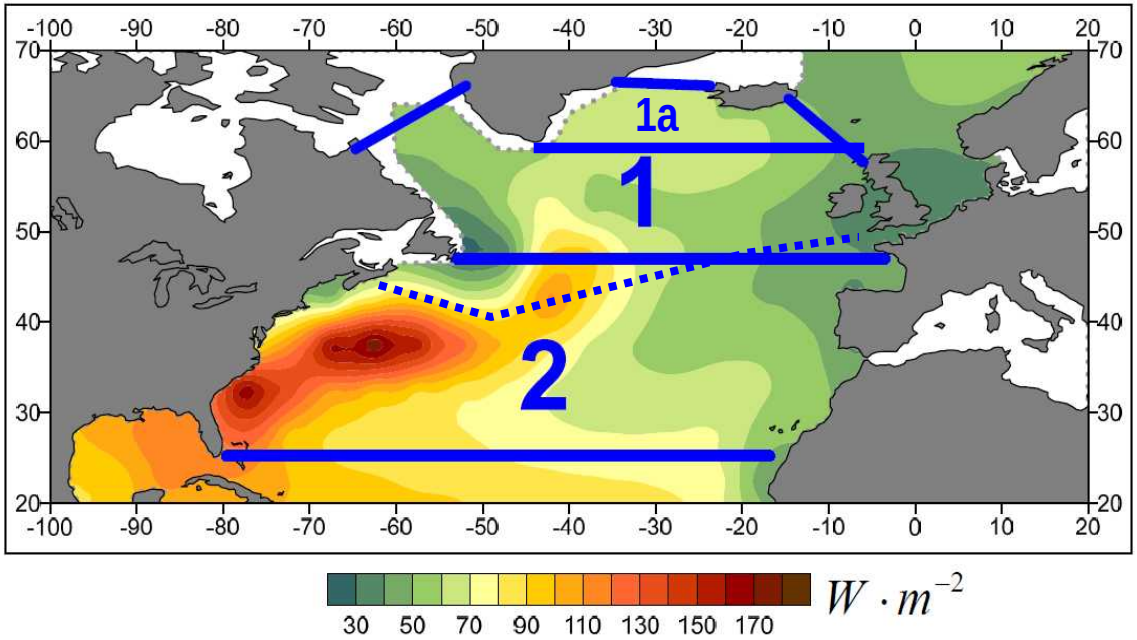
Special subtask – modelling individual extremely high flux events with non-hydrostatic formulations (case studies) → high resolution fluxes and flux related parameters → use of the output for generating error estimator for extreme fluxes

Caveat – easily doable, but not a cheap task
Q – do we need this?

Contribution to TIE-OHF

Task 3 – product generation, intercomparison and uncertainties

Cages – guidance for selection – North Atlantic



Comment – 48/52 N is somewhat different from a line (see dash)
Sampling –

25.5 N – to present
48/52 N – 1990s – early 2000s
60 N – 1997 (93) – to present
Lab Sea – to present (talk to BIO – Yasjhayaev)

Approaches –

Use ocean state estimates to generate imbalances (O-I)
Use ensemble of surface flux estimates to generate (A-I)
Use hydrographic sections to generate imbalances (H-I)

→ Multivariative analysis (space-time) to get the insights on closure
Q – Role of ARGO?

Contribution to TIE-OHF

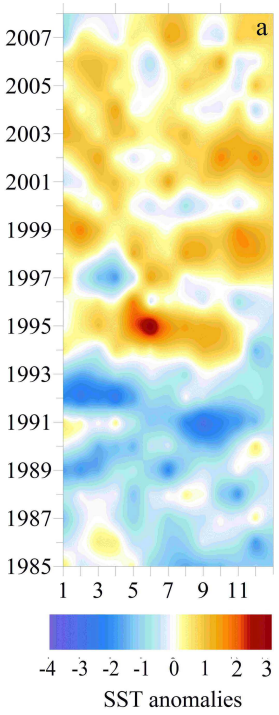
Task 3 – product generation, intercomparison and uncertainties

Cages – guidance for selection – Enclosed Seas

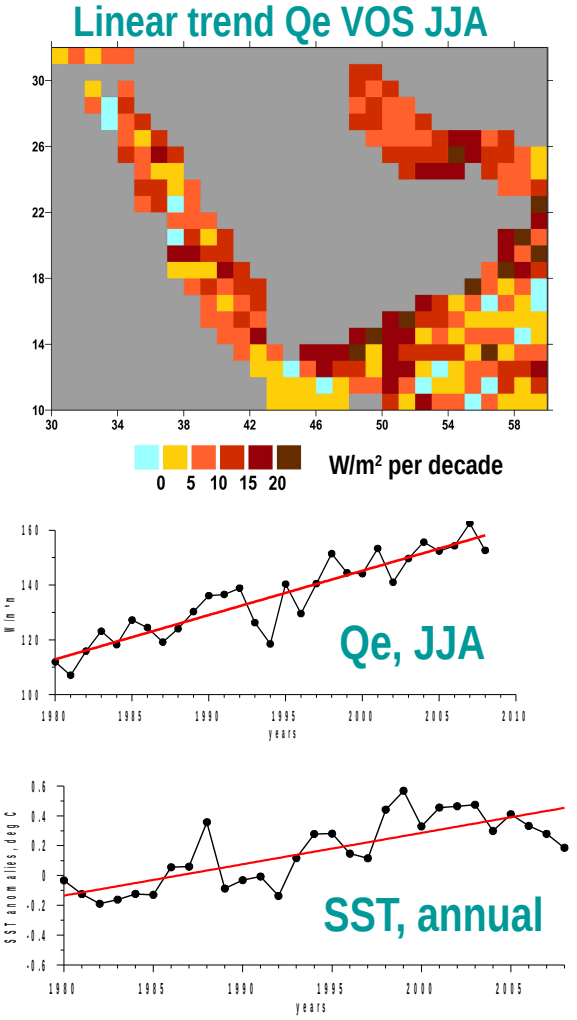
Meddi
Black
Red + Gulf (or not)
Great Lakes
Q1: What else?

Q2:
(i) How effective the retrievals here?
(ii) How good is the data coverage (VOS)?
(iii) River/ground water inflow? Where from?
(iv) Robust estimates of inflow/outflow (instrumental)

Action – need for the test case study(ies)
Q3: what think? Task group?



Raitsos et al., 2011



Gulev et al., 2014, unpub

Budget issues -

Q:

Who is managing budget for WHOI, Maryland, IORAS? IFREMER?
Personnel and travel exclusively, or also other costs?