Challenges in climate monitoring of latent heat flux and related parameters

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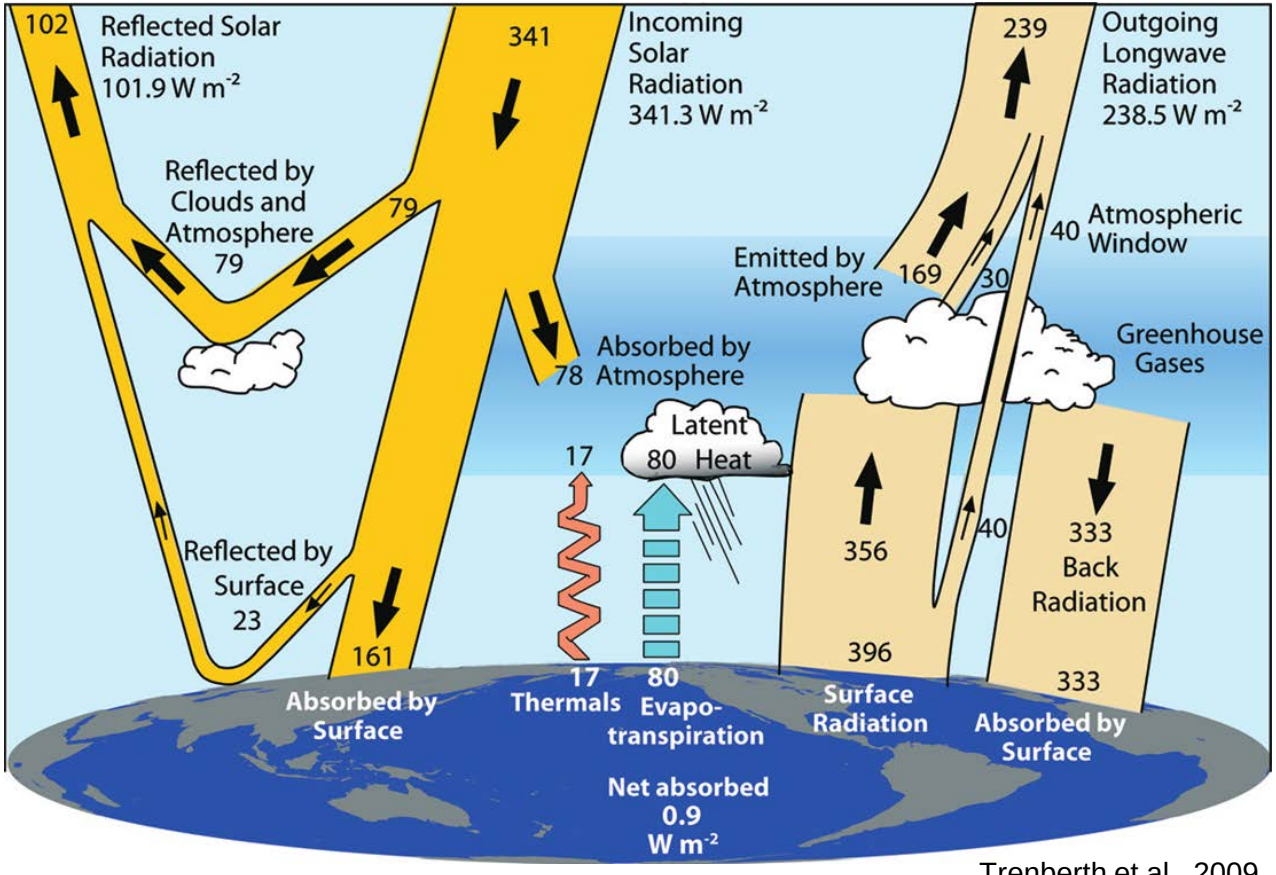
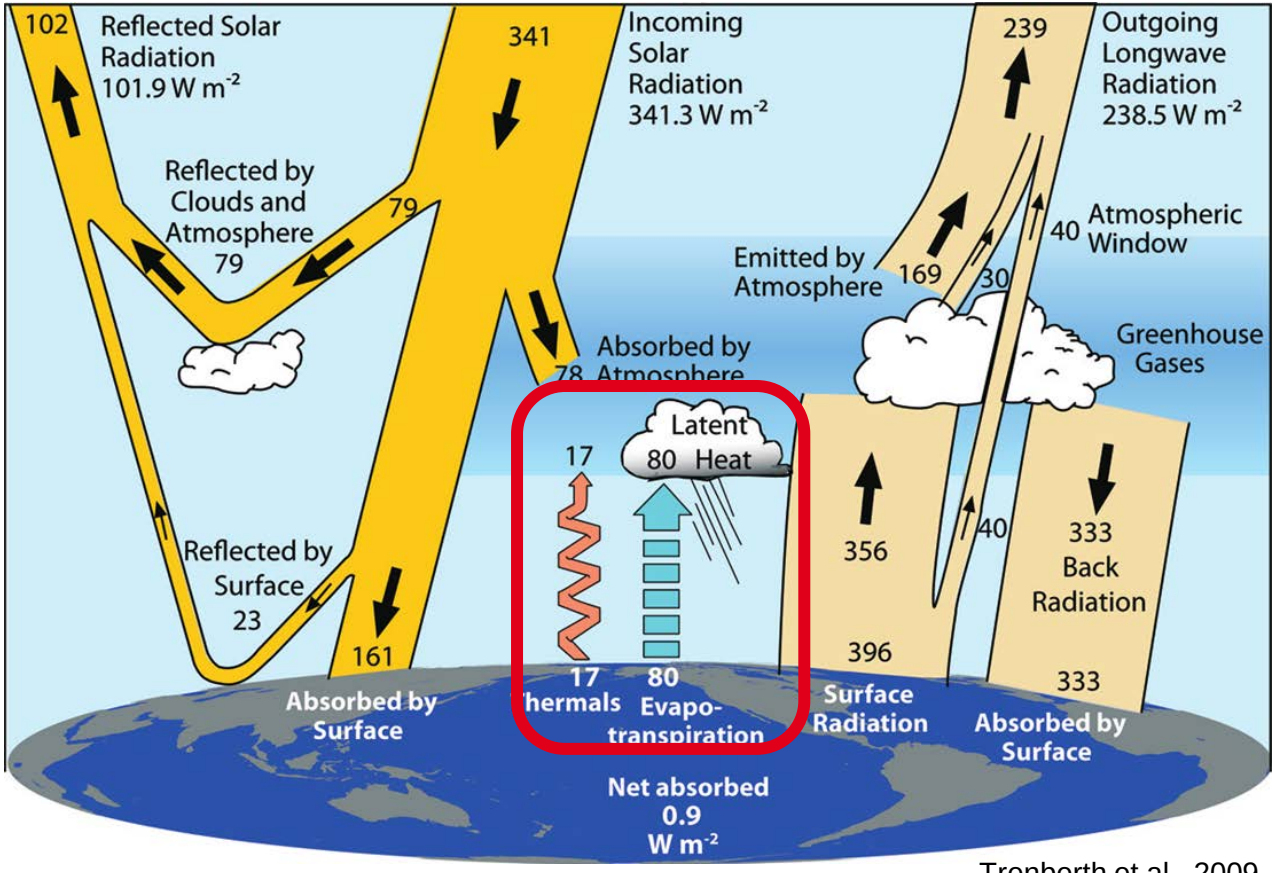
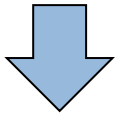


Trenberth et al., 2009



Trenberth et al., 2009

- Knowledge of global water cycle components is crucial for understanding of the climate system
- What is the temporal and spatial variability of essential water cycle components?



- TCDRs needed

Calculation of Latent Heat Flux (Ocean)

Derived using bulk formula:

- $Q_l = \rho_a L_E C_E U (q_s - q_a)$

- U: near surface wind speed
- q_a: near surface specific humidity
- q_s: sea surface saturation specific humidity (estimated from SST)
- C_E: latent heat transfer coefficient (*parameterization)*
- ρ_a*: air density*
- L_E*:* specific latent heat of evaporation
- air temperature: measurement, estimated from SST, humidity

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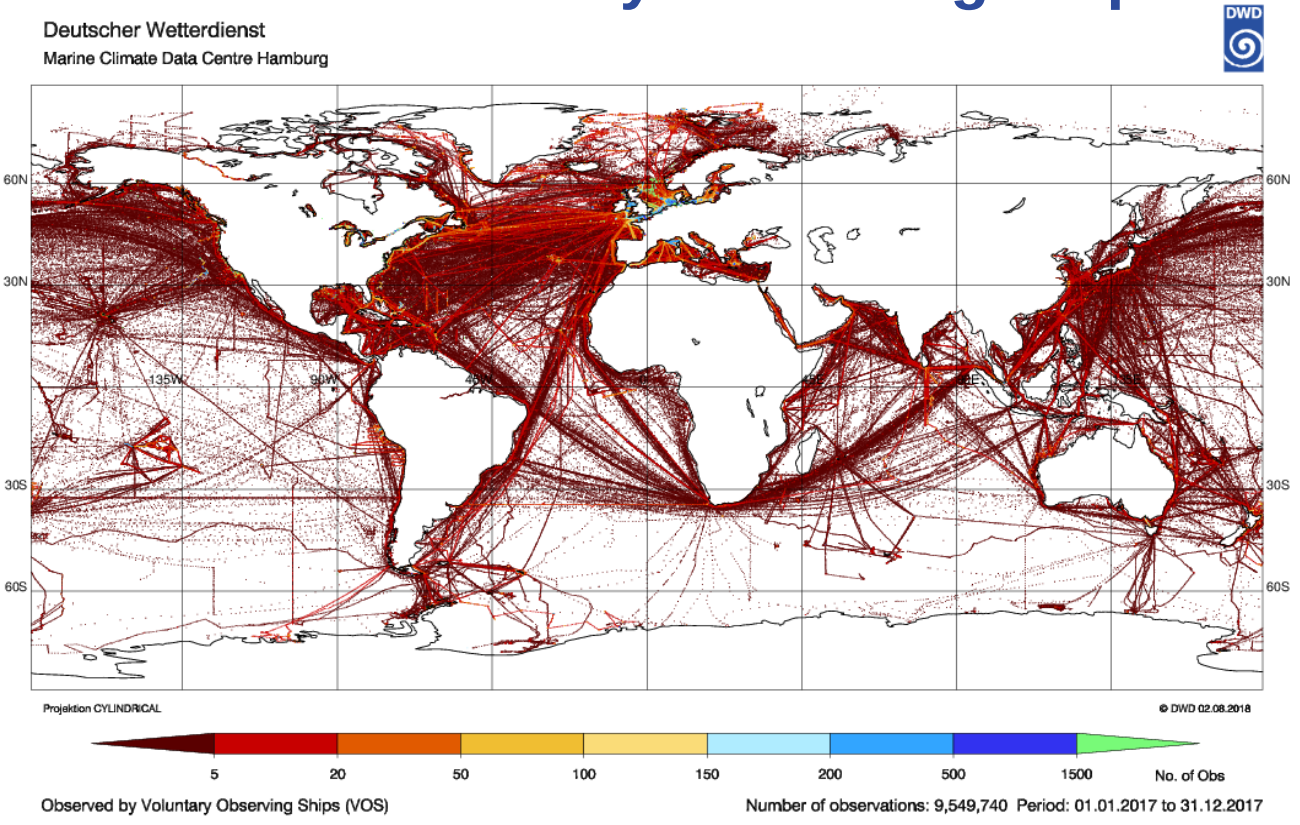
Data Sources (Ocean)

- In-situ data from ships / buoys

DWD Marine Data Centre

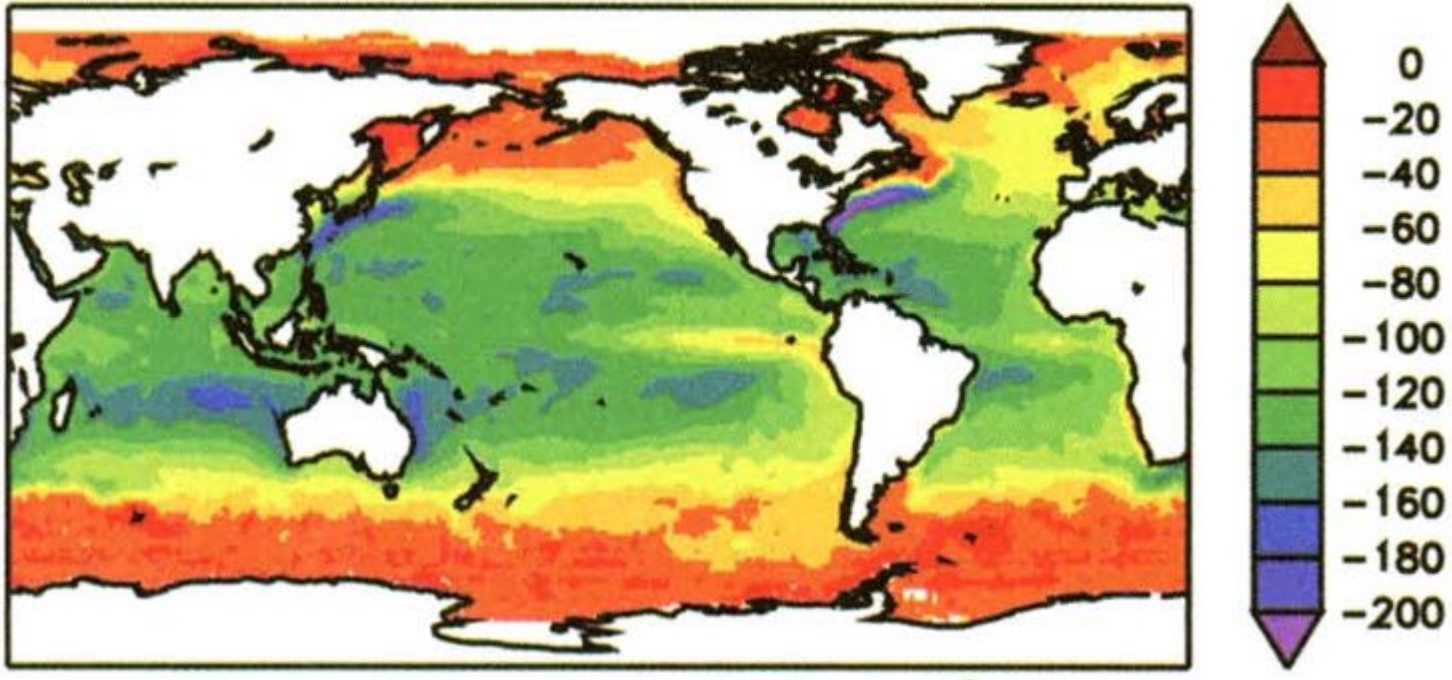
- National centre for oceanic data from ships, buoys, other platforms
- Collection and provision of quality controlled marine meteorological data
- Historical archive
- „Modern“ data (VOS + GTS/NRT)
- International exchange of data collected by VOS in the framework of the JCOMM Marine Climate Data System (MCDS)
- Redistribution of data through WMO data centres -> input for ICOADS

Data Distribution – Voluntary Observing Ships



NOC Surface Flux and Meteorological Dataset

Climatological mean latent heat flux [W/m²]



Berry, 2009, BAMS

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- In-situ data from ships / buoys
  - Long data record
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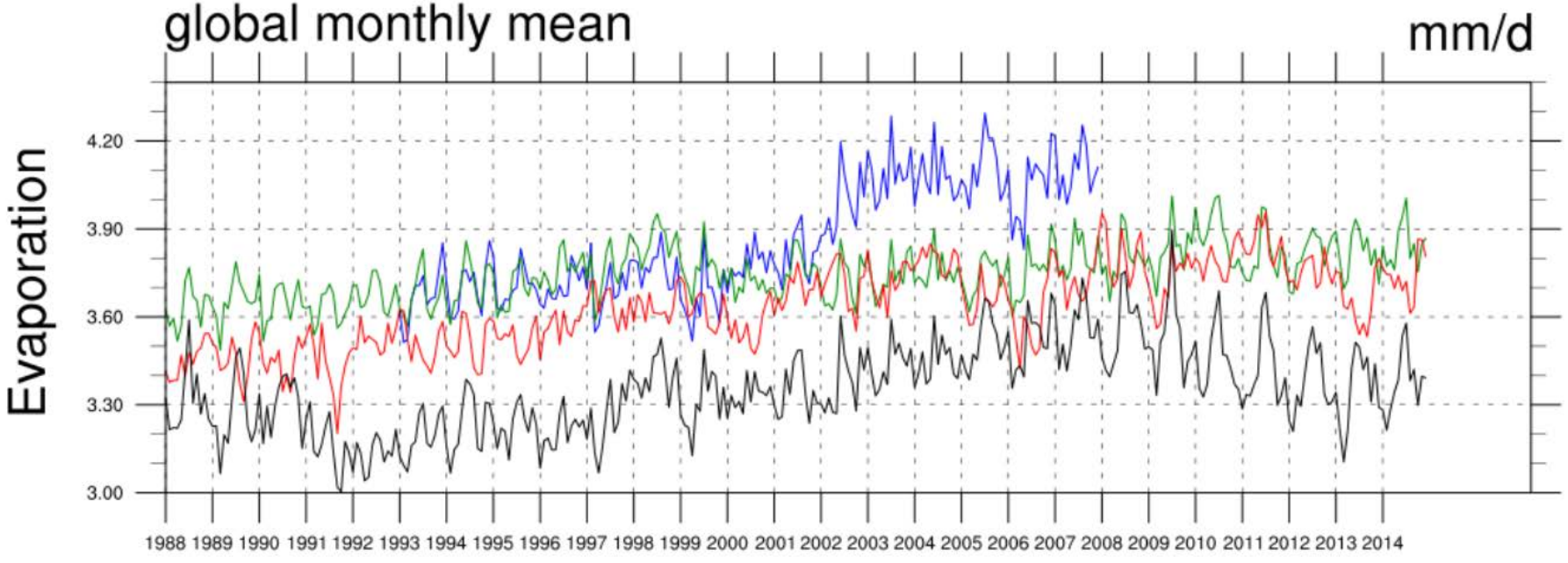
- Satellite data
  - provide global coverage in space and time
  - Passive microwave satellite instruments can be used to derive water cycle components (water vapor, precipitation and evaporation)
- CMSAF:
  HOAPS (Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite Data)

Data records



HOAPS 4.0 (CM SAF)
ERA-int
NOC
IFREMER

validation / evaluation / uncertainty quantification

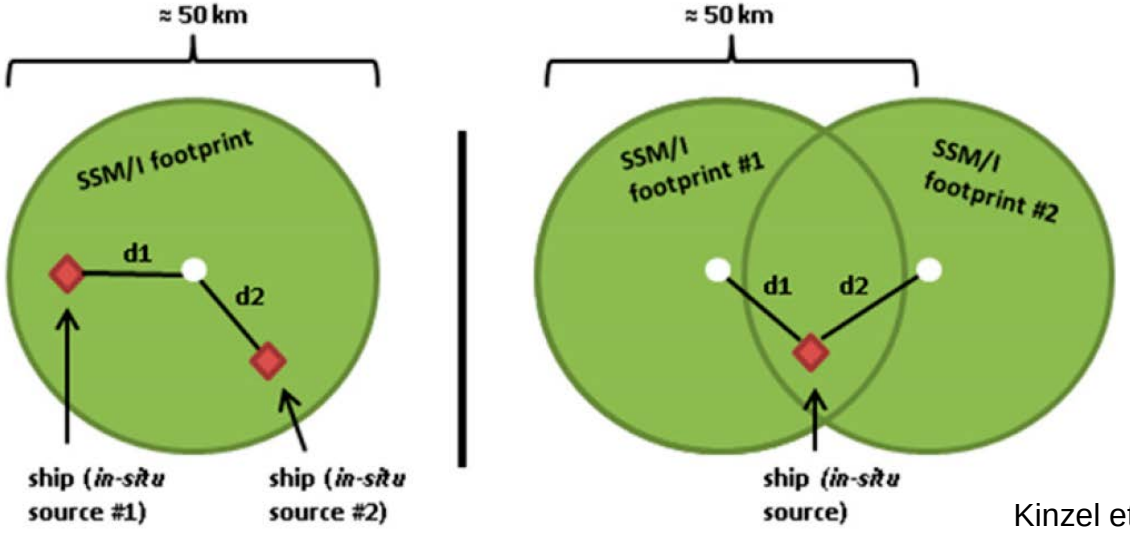
- „Ground truth“ data needed:
  - In-situ measurements from ships / buoys
  - Thorough QC required
  - Meta data essential

- error model for satellite TCDR from instrument uncertainty to aggregated monthly fields

Uncertainty Estimation

➔ Error decomposition via collocation of in-situ and satellite data for uncertainty characterization of HOAPS.

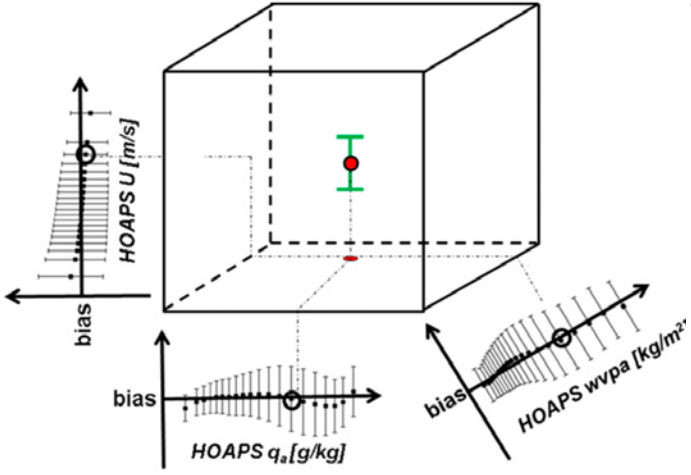
Ship data from the Marine Data Centre of DWD and ICOADS, satellite data from HOAPS.

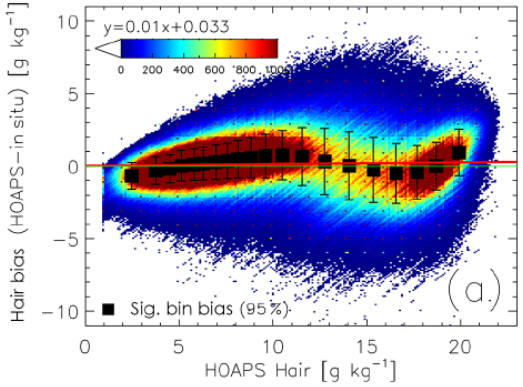


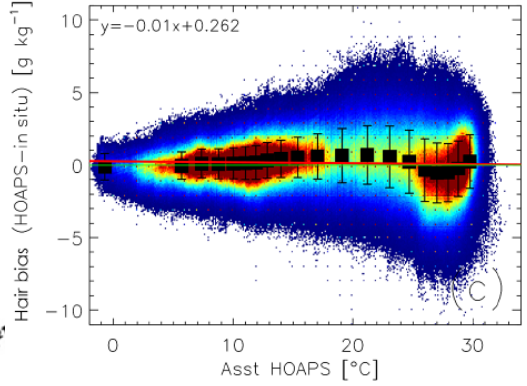
Kinzel et al., 2016

Uncertainty Estimation

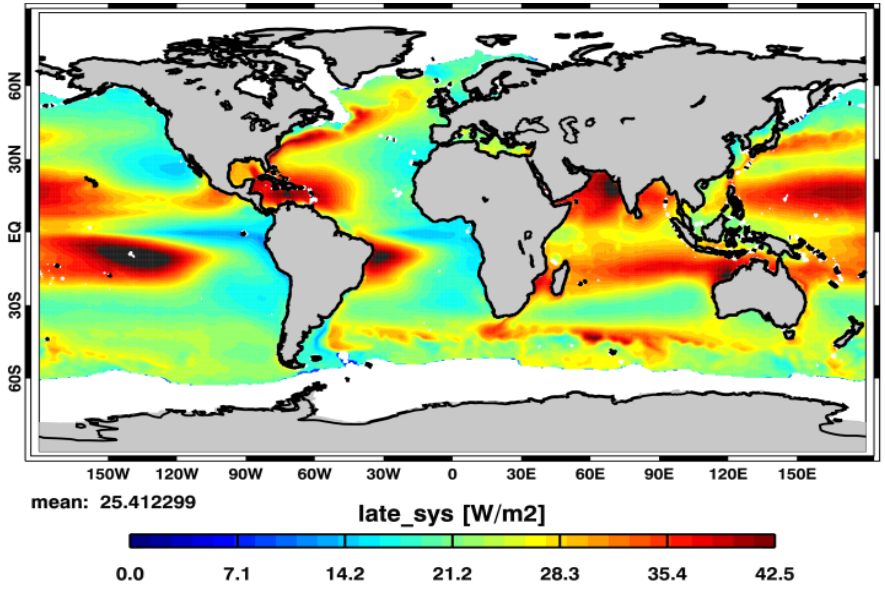
- Multi-dimensional bias analysis (Liman et al., 2018, bias relative to ship data as function of TCWV, wind, q_a, SST): get bias and standard deviation in multidimensional space.
- Remove in-situ and collocation uncertainty to get retrieval uncertainty.



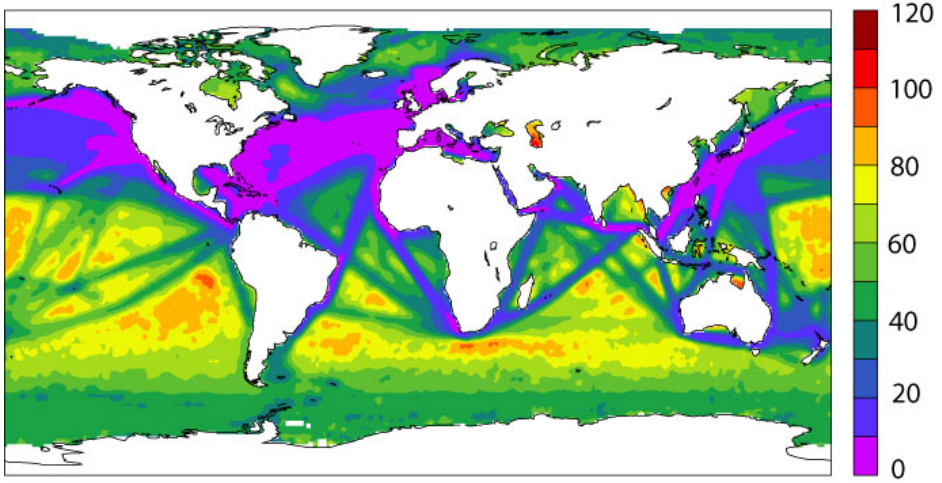




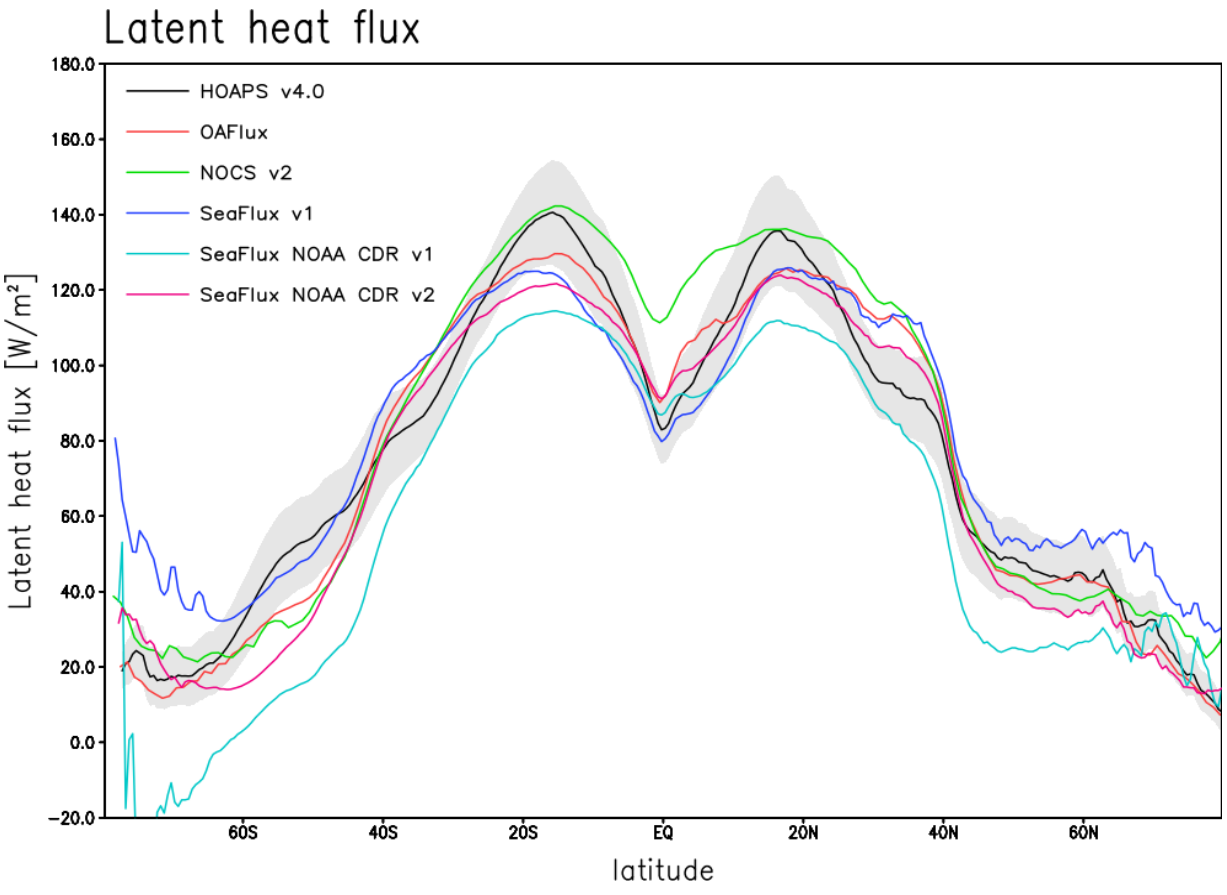
Uncertainty Estimation



HOAPS *mean uncertainty (Wm^{-2}) in the monthly mean net latent heat fluxes.*



NOC *mean uncertainty (Wm^{-2}) in the monthly mean net heat fluxes.*


Latent heat flux
HOAPS v4.0
OAFlux
NOCS v2
SeaFlux v1
SeaFlux NOAA CDR v1
SeaFlux NOAA CDR v2
Latent heat flux [W/m²]
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
−20.0
60S
40S
20S
EQ
20N
40N
60N
latitude

Summary

Satellite data records for turbulent heat fluxes over ocean cover 25+ years

- ➔ Still significant differences between data records, although derived from the same satellite instruments

- ➔ Uncertainty estimation
  - ➔ Methodology has been developed for HOAPS
  - ➔ Point to area problem (Satellite pixel vs. Point measurement)
  - ➔ Quality of in-situ data?
- ➔ How to use the uncertainty information?

- ➔ Long term stability? -> FCDRs required

Outlook

- Latent heat flux (evapotranspiration) over land
- Combine ocean and land fluxes