Assessment of wetlands extend and sensitivity of the land surface simulations to the extent of the water bodies

Goran Georgievski, Stefan Hagemann and Tobias Stacke

Max Planck Institute for Meteorology
goran.georgievski@mpimet.mpg.de

Frascati, 19. 3. 2015.

Outline

1. Introduction
   - Objective
   - JSBACH land surface scheme
   - WEED implementation $\rightarrow$ JSBACH
2. Wetlands models and observations
   - ESA-CCI-LC Water Body
   - MPI-HM, JSBACH and observations
3. Wetlands comparison
   - Geospatial distribution
   - Continental distribution
   - Zonal distribution
   - Spatial correlation
4. LSM comparison
   - Geospatial distribution
   - Evapotranspiration and runoff - annual mean biases
   - Evapotranspiration and runoff - annual cycle

Outline

1. Introduction
   - Objective
   - JSBACH land surface scheme
   - WEED implementation $\rightarrow$ JSBACH
2. Wetlands models and observations
   - ESA-CCI-LC Water Body
   - MPI-HM, JSBACH and observations
3. Wetlands comparison
   - Geospatial distribution
   - Continental distribution
   - Zonal distribution
   - Spatial correlation
4. LSM comparison
   - Geospatial distribution
   - Evapotranspiration and runoff - annual mean biases
   - Evapotranspiration and runoff - annual cycle

Outline

1. Introduction
   - Objective
   - JSBACH land surface scheme
   - WEED implementation $\rightarrow$ JSBACH
2. Wetlands models and observations
   - ESA-CCI-LC Water Body
   - MPI-HM, JSBACH and observations
3. Wetlands comparison
   - Geospatial distribution
   - Continental distribution
   - Zonal distribution
   - Spatial correlation
4. LSM comparison
   - Geospatial distribution
   - Evapotranspiration and runoff - annual mean biases
   - Evapotranspiration and runoff - annual cycle

Outline

1. Introduction
   - Objective
   - JSBACH land surface scheme
   - WEED implementation $\rightarrow$ JSBACH
2. Wetlands models and observations
   - ESA-CCI-LC Water Body
   - MPI-HM, JSBACH and observations
3. Wetlands comparison
   - Geospatial distribution
   - Continental distribution
   - Zonal distribution
   - Spatial correlation
4. LSM comparison
   - Geospatial distribution
   - Evapotranspiration and runoff - annual mean biases
   - Evapotranspiration and runoff - annual cycle

Outline

1. Introduction
   - Objective
   - JSBACH land surface scheme
   - WEED implementation $\rightarrow$ JSBACH
2. Wetlands models and observations
   - ESA-CCI-LC Water Body
   - MPI-HM, JSBACH and observations
3. Wetlands comparison
   - Geospatial distribution
   - Continental distribution
   - Zonal distribution
   - Spatial correlation
4. LSM comparison
   - Geospatial distribution
   - Evapotranspiration and runoff - annual mean biases
   - Evapotranspiration and runoff - annual cycle

Threefold assessment of ESA-CCI-LC WB product

In the frame of ESA-CCI-LC project new water bodies data are released. In this study the sensitivity of land surface simulations to the treatment of water bodies is investigated. For that purpose the assessment of ESA-CCI-LC WB product is threefold:

- comparison of ESA-CCI-LC WB with other available observations
- comparison with surface water bodies generated by the JSBACH-WEED and the MPI hydrologic model (MPI-HM)
- in the context of climate simulation as a prescribed wetland boundary condition for JSBACH land surface simulation

Outline

1. Introduction
   - Objective
   - JSBACH land surface scheme
   - WEED implementation → JSBACH
2. Wetlands models and observations
   - ESA-CCI-LC Water Body
   - MPI-HM, JSBACH and observations
3. Wetlands comparison
   - Geospatial distribution
   - Continental distribution
   - Zonal distribution
   - Spatial correlation
4. LSM comparison
   - Geospatial distribution
   - Evapotranspiration and runoff - annual mean biases
   - Evapotranspiration and runoff - annual cycle

JSBACH land surface scheme

LSM lower atmospheric boundary condition over land in ESM, but also offline mode possible (WFDEI). Controls the partitioning of available:

- energy at the surface (sensible and latent heat)
- water (evaporation and runoff)
- Carbon in terrestrial pools
- recent development:
  - new soil Carbon scheme (Yasso)
  - 5 layer soil hydrology (Hagemann and Stacke 2014)
  - Stacke and Hagemann (2012): Development and evaluation of a global dynamical wetlands extent scheme $\rightarrow$ JSBACH implementation

Outline

1. Introduction
   - Objective
   - JSBACH land surface scheme
   - WEED implementation → JSBACH
2. Wetlands models and observations
   - ESA-CCI-LC Water Body
   - MPI-HM, JSBACH and observations
3. Wetlands comparison
   - Geospatial distribution
   - Continental distribution
   - Zonal distribution
   - Spatial correlation
4. LSM comparison
   - Geospatial distribution
   - Evapotranspiration and runoff - annual mean biases
   - Evapotranspiration and runoff - annual cycle

JSBACH WEED implementation: Overview

JSBACH with **WE**tland **E**xtent **D**ynamics

- Simulates wetland extent and depth dynamically
- Solves water balance to compute excess surface water
- Distributes water based on subgrid slope distribution

Development status in JSBACH

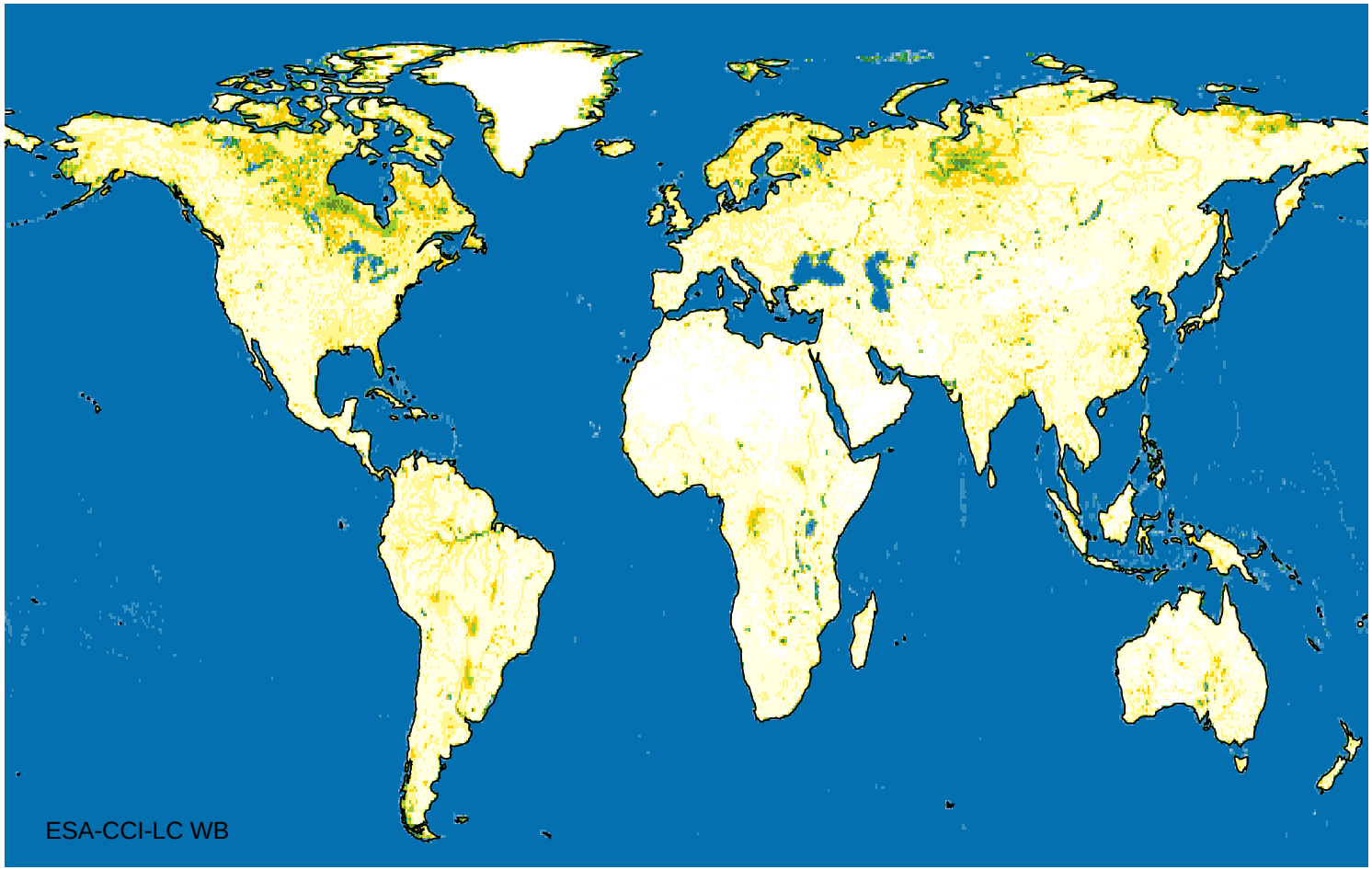
Topic	Concept	Tested	JSBACH
Excess surface water	✔	✔	✔
Vertical water flows	✔	✔	✔
Horizontal wetland dynamics	✔	✔	✔
Lateral water flows	✎	✎	✎
Global parameter tuning	✔	✔	✎
Albedo and heat capacity	✗	✗	✗

Outline

1. Introduction
   - Objective
   - JSBACH land surface scheme
   - WEED implementation → JSBACH
2. Wetlands models and observations
   - ESA-CCI-LC Water Body
   - MPI-HM, JSBACH and observations
3. Wetlands comparison
   - Geospatial distribution
   - Continental distribution
   - Zonal distribution
   - Spatial correlation
4. LSM comparison
   - Geospatial distribution
   - Evapotranspiration and runoff - annual mean biases
   - Evapotranspiration and runoff - annual cycle

ESA-CCI-LC WB

Permanent open water bodies, ENVISAT-ASAR 2005 - 2010, 300m $\rightarrow$ 0.5°



Outline

1. Introduction
   - Objective
   - JSBACH land surface scheme
   - WEED implementation → JSBACH
2. Wetlands models and observations
   - ESA-CCI-LC Water Body
   - MPI-HM, JSBACH and observations
3. Wetlands comparison
   - Geospatial distribution
   - Continental distribution
   - Zonal distribution
   - Spatial correlation
4. LSM comparison
   - Geospatial distribution
   - Evapotranspiration and runoff - annual mean biases
   - Evapotranspiration and runoff - annual cycle

Global Lake and Wetl DB - **GLWD**

Lehner and Döll (2004) compilation, max extend of lakes, reservoirs, rivers and wetlands 12 classes at 30″

Land Surface Param 2 - **LSP2**

Hagemann et al (1999, 2002) derived from the Global Land Cover Characteristics Database at 1 km

Wetland ecosystem map - **MATT**

Matthews and Fung (1987) field data and aerial photo max extend of 5 wetland types; distinguished at 1° resolution

Satellite Derived Inundation - **SIND**

Prigent et al (2001, 2007) and Papa et al (2010) 12yr active and passive MW, VIS and near-IR imagery at 0.25°

MPI Hydrological Model - **MPI-HM**

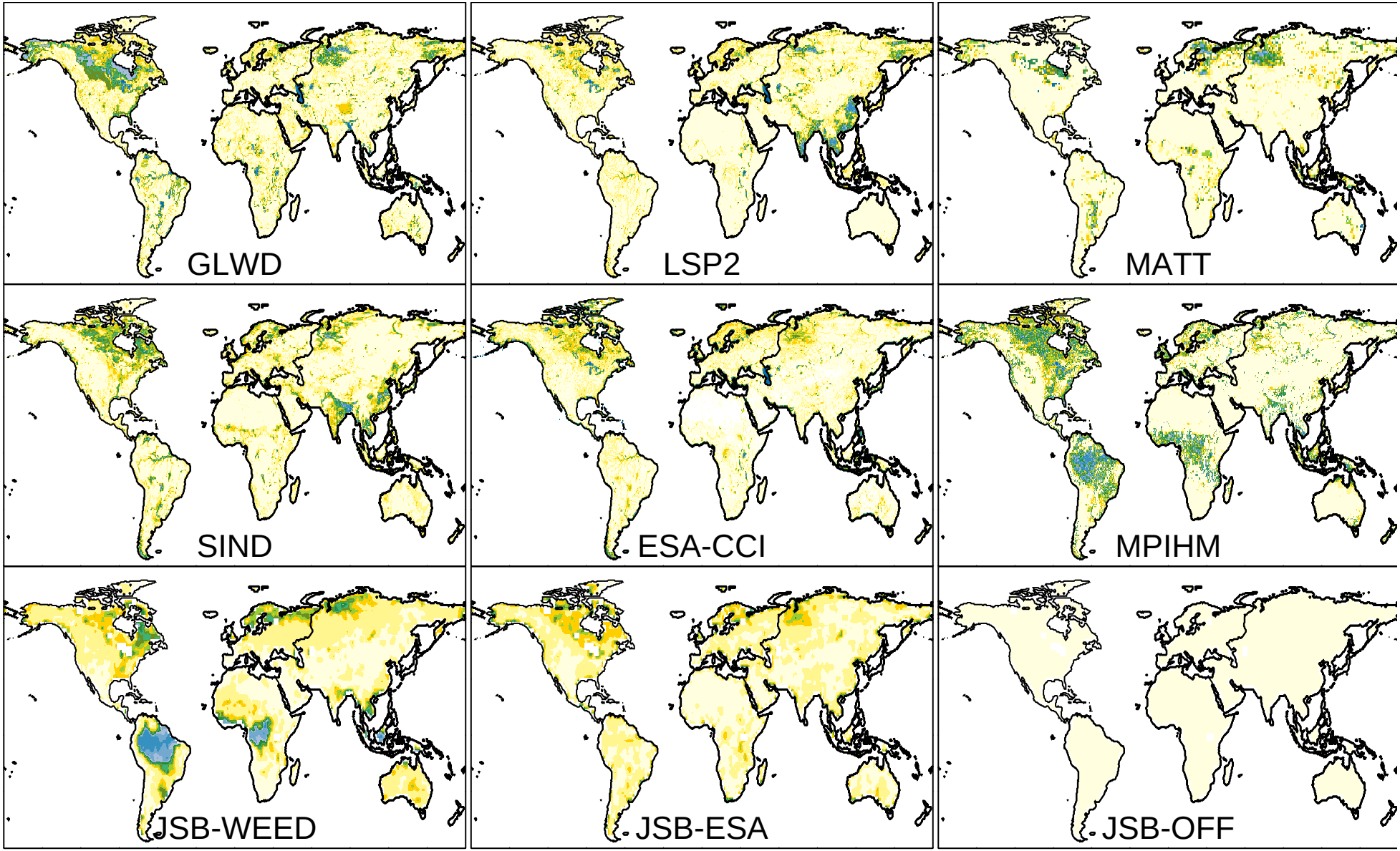
Stacke and Hagemann (2012) offline HM driven by WATCH (T&P) (5 yr spin-up) 1958-1999 at 0.5° – NOWL

Land surface scheme - **JSBACH**

3 WFDEI driven simulations for period 1979–2009; WEED, REF, ESA at T63 (∼1.875°) resolution

Outline

1. Introduction
   - Objective
   - JSBACH land surface scheme
   - WEED implementation → JSBACH
2. Wetlands models and observations
   - ESA-CCI-LC Water Body
   - MPI-HM, JSBACH and observations
3. Wetlands comparison
   - Geospatial distribution
   - Continental distribution
   - Zonal distribution
   - Spatial correlation
4. LSM comparison
   - Geospatial distribution
   - Evapotranspiration and runoff - annual mean biases
   - Evapotranspiration and runoff - annual cycle

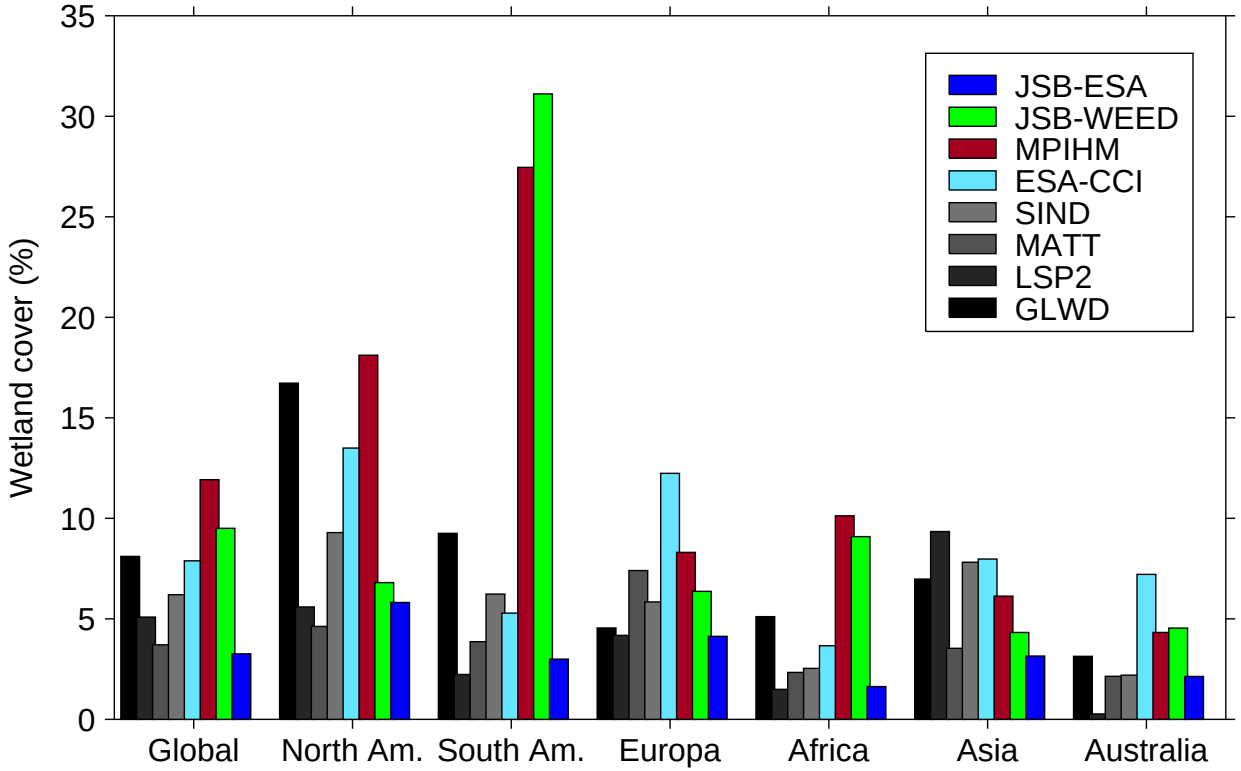

GLWD
LSP2
MATT
SIND
ESA-CCI
MPIHM
JSB-WEED
JSB-ESA
JSB-OFF
0.00
0.01
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Wetland fraction

Outline

1. Introduction
   - Objective
   - JSBACH land surface scheme
   - WEED implementation $\rightarrow$ JSBACH
2. Wetlands models and observations
   - ESA-CCI-LC Water Body
   - MPI-HM, JSBACH and observations
3. Wetlands comparison
   - Geospatial distribution
   - Continental distribution
   - Zonal distribution
   - Spatial correlation
4. LSM comparison
   - Geospatial distribution
   - Evapotranspiration and runoff - annual mean biases
   - Evapotranspiration and runoff - annual cycle

Continental distributions of wetlands

in percent of global land surface without Antarctica

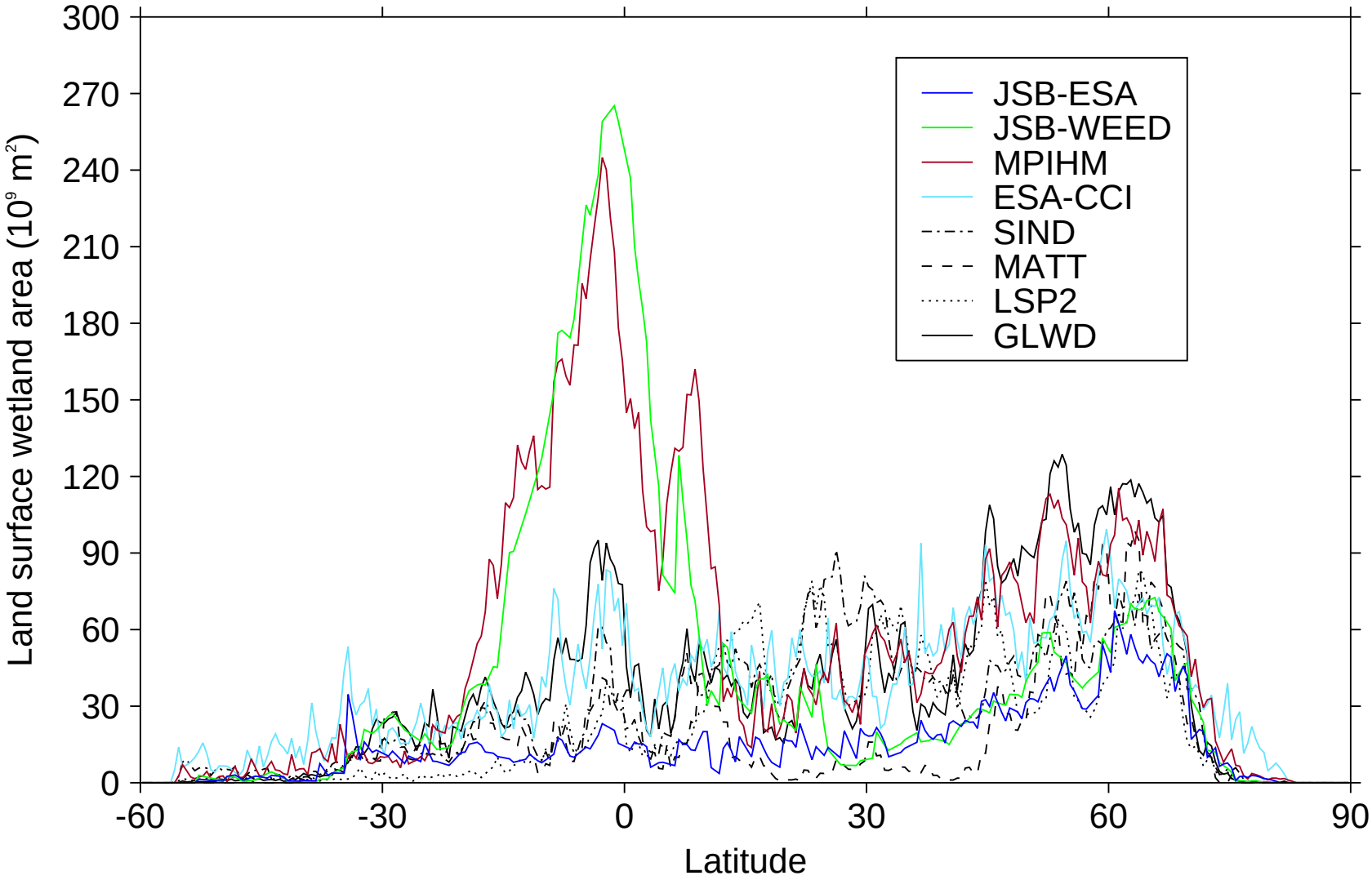


Continent	GLWD	LSP2	MATT	SIND	ESA-CCI	MPIHM	JSB-WEED	JSB-ESA
North America	16.72	5.59	4.62	9.29	13.50	18.11	6.80	5.81
South America	9.25	2.23	3.86	6.23	5.29	27.46	31.11	3.00
Europa	4.55	4.18	7.40	5.84	12.24	8.31	6.37	4.13
Africa	5.11	1.49	2.34	2.54	3.66	10.13	9.09	1.63
Asia	6.98	9.34	3.53	7.82	7.98	6.13	4.32	3.15
Australia	3.14	0.27	2.14	2.20	7.21	4.32	4.54	2.13
Global	8.11	5.09	3.71	6.20	7.89	11.92	9.50	3.26

Outline

1. Introduction
   - Objective
   - JSBACH land surface scheme
   - WEED implementation $\rightarrow$ JSBACH
2. Wetlands models and observations
   - ESA-CCI-LC Water Body
   - MPI-HM, JSBACH and observations
3. Wetlands comparison
   - Geospatial distribution
   - Continental distribution
   - Zonal distribution
   - Spatial correlation
4. LSM comparison
   - Geospatial distribution
   - Evapotranspiration and runoff - annual mean biases
   - Evapotranspiration and runoff - annual cycle

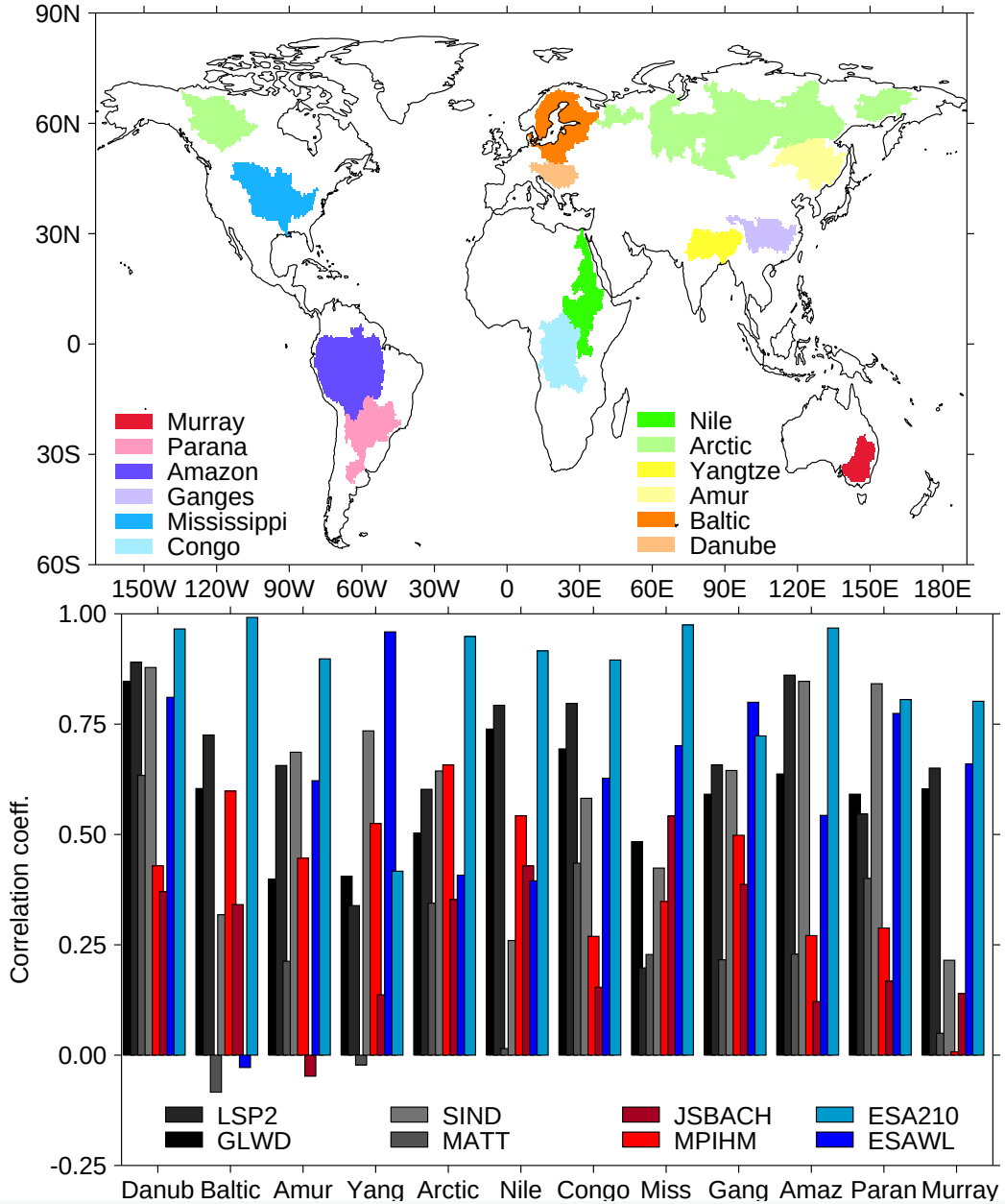
Zonal distribution of wetlands



Outline

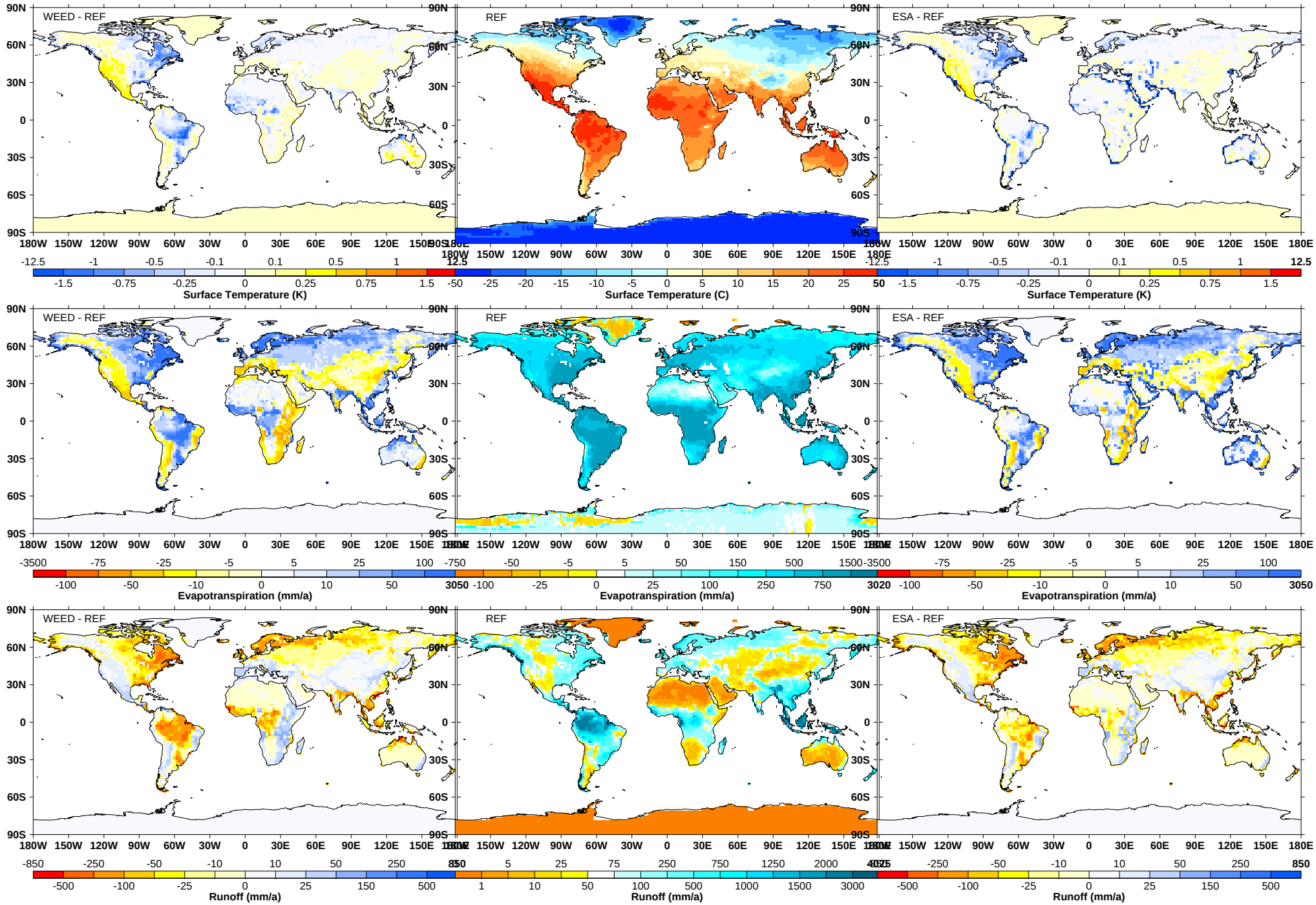
1. Introduction
   - Objective
   - JSBACH land surface scheme
   - WEED implementation $\rightarrow$ JSBACH
2. Wetlands models and observations
   - ESA-CCI-LC Water Body
   - MPI-HM, JSBACH and observations
3. Wetlands comparison
   - Geospatial distribution
   - Continental distribution
   - Zonal distribution
   - Spatial correlation
4. LSM comparison
   - Geospatial distribution
   - Evapotranspiration and runoff - annual mean biases
   - Evapotranspiration and runoff - annual cycle

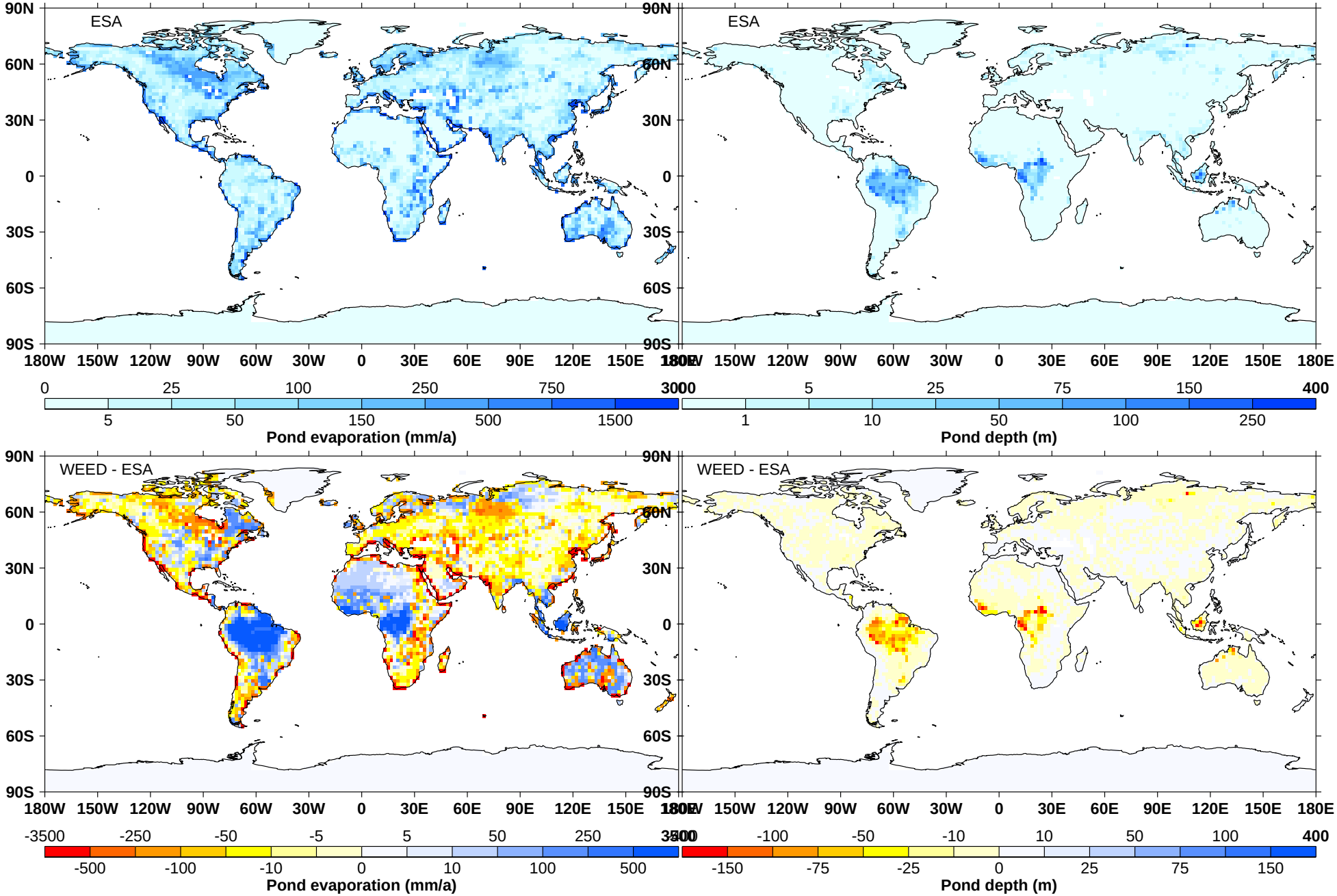
Spatial correlation for major catchments



Outline

1. Introduction
   - Objective
   - JSBACH land surface scheme
   - WEED implementation → JSBACH
2. Wetlands models and observations
   - ESA-CCI-LC Water Body
   - MPI-HM, JSBACH and observations
3. Wetlands comparison
   - Geospatial distribution
   - Continental distribution
   - Zonal distribution
   - Spatial correlation
4. LSM comparison
   - Geospatial distribution
   - Evapotranspiration and runoff - annual mean biases
   - Evapotranspiration and runoff - annual cycle

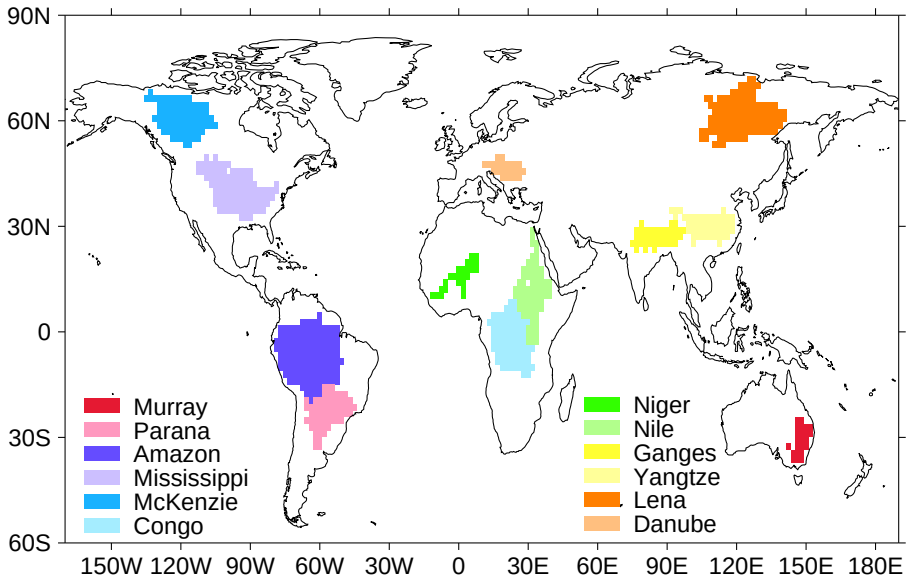

WEED - REF
REF
ESA - REF
Surface Temperature (K)
Surface Temperature (C)
Surface Temperature (K)
Evapotranspiration (mm/a)
Evapotranspiration (mm/a)
Evapotranspiration (mm/a)
Runoff (mm/a)
Runoff (mm/a)
Runoff (mm/a)

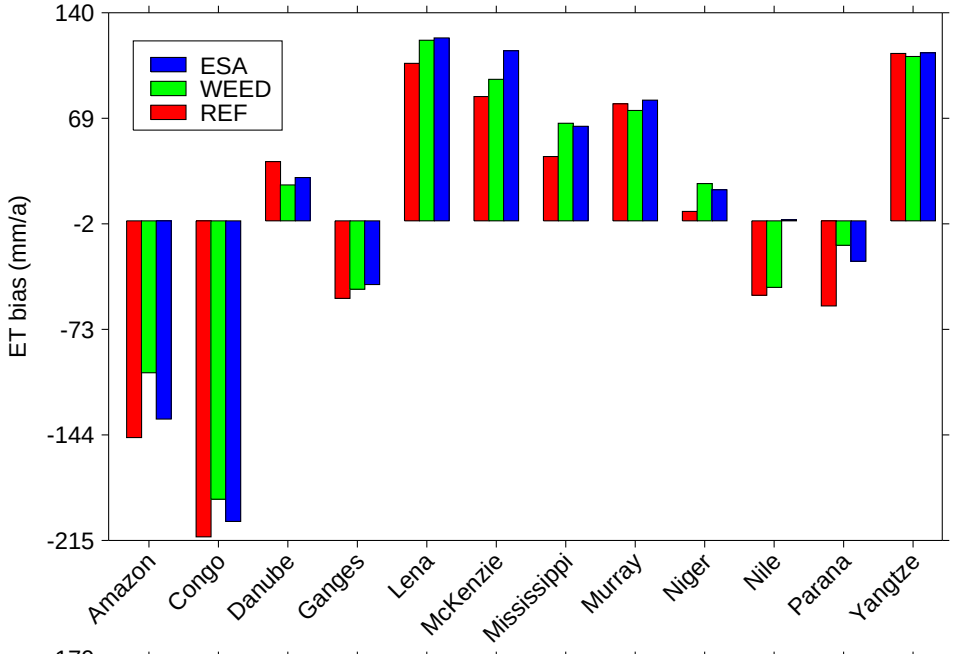

ESA
ESA
WEED - ESA
WEED - ESA
90N
60N
30N
0
30S
60S
90S
180W 150W 120W 90W 60W 30W 0 30E 60E 90E 120E 150E 180E
0 25 100 250 750 3000
5 50 150 500 1500
Pond evaporation (mm/a)
0 5 25 75 150 400
1 10 50 100 250
Pond depth (m)
-3500 -250 -50 -5 5 50 250 3500
-500 -100 -10 0 10 100 500
Pond evaporation (mm/a)
-400 -100 -50 -10 10 50 100 400
-150 -75 -25 0 25 75 150
Pond depth (m)

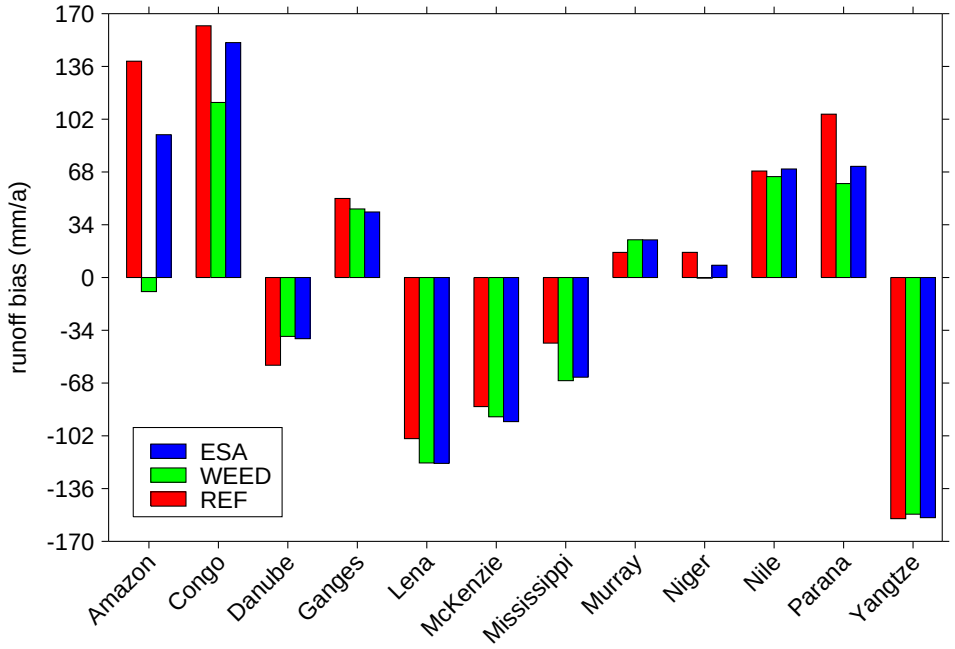
Outline

1. Introduction
   - Objective
   - JSBACH land surface scheme
   - WEED implementation $\rightarrow$ JSBACH
2. Wetlands models and observations
   - ESA-CCI-LC Water Body
   - MPI-HM, JSBACH and observations
3. Wetlands comparison
   - Geospatial distribution
   - Continental distribution
   - Zonal distribution
   - Spatial correlation
4. LSM comparison
   - Geospatial distribution
   - Evapotranspiration and runoff - annual mean biases
   - Evapotranspiration and runoff - annual cycle

Annual mean biases



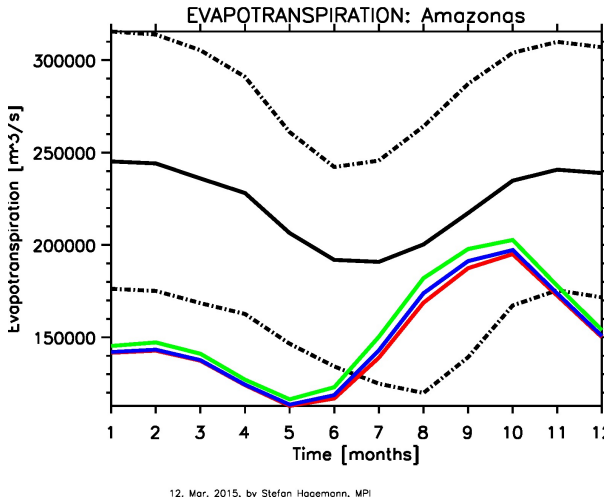


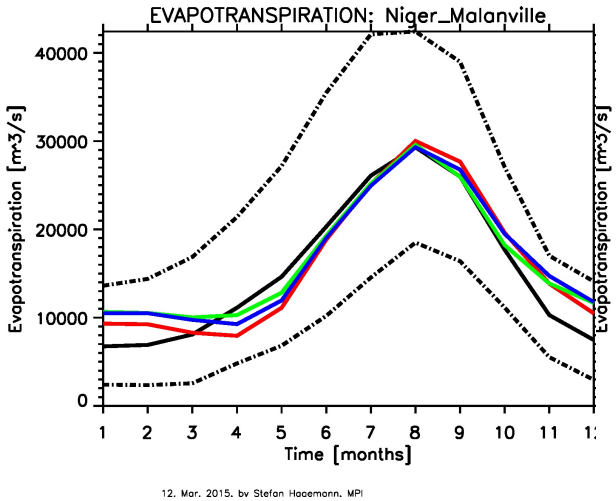


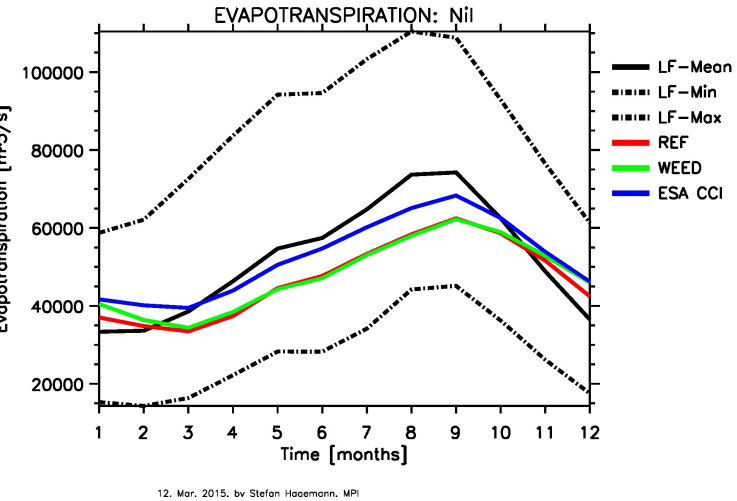
Outline

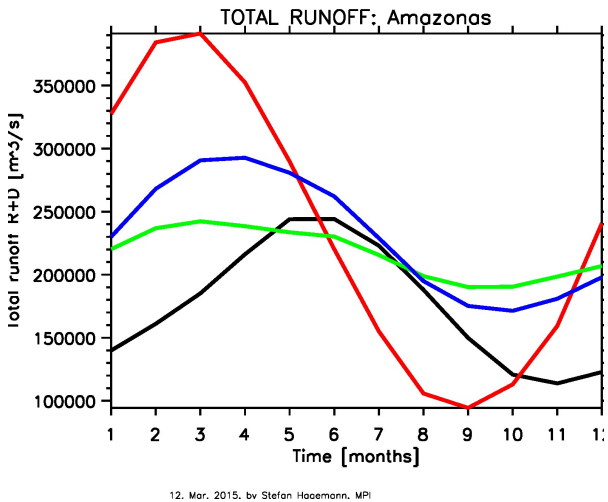
1. Introduction
   - Objective
   - JSBACH land surface scheme
   - WEED implementation $\rightarrow$ JSBACH
2. Wetlands models and observations
   - ESA-CCI-LC Water Body
   - MPI-HM, JSBACH and observations
3. Wetlands comparison
   - Geospatial distribution
   - Continental distribution
   - Zonal distribution
   - Spatial correlation
4. LSM comparison
   - Geospatial distribution
   - Evapotranspiration and runoff - annual mean biases
   - Evapotranspiration and runoff - annual cycle

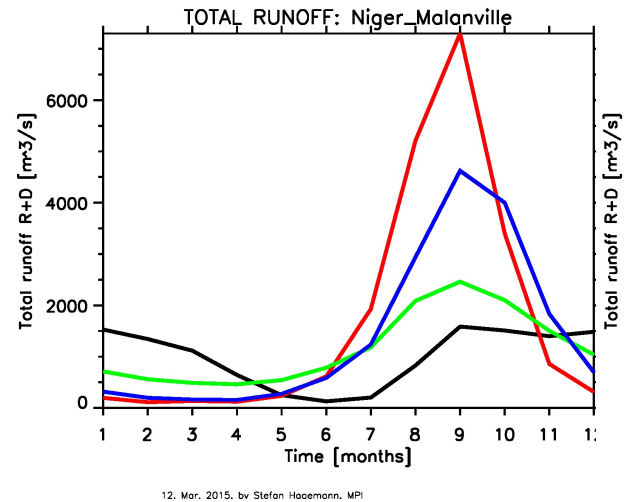
Evapotranspiration and runoff annual cycle

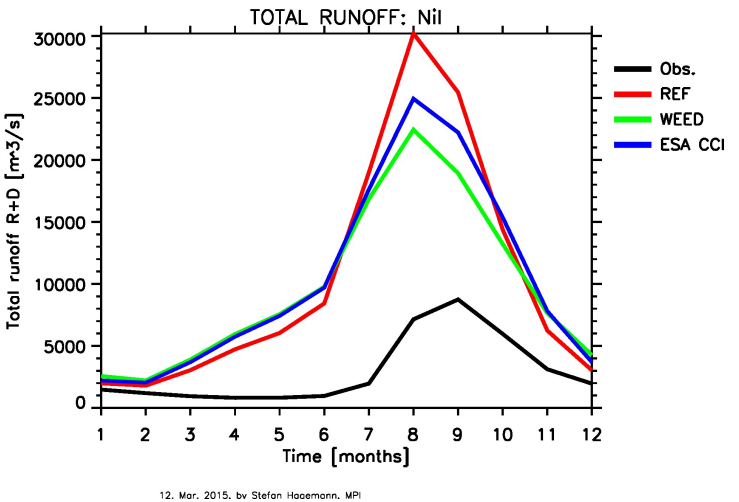












Summary and discussion

- wetlands data - differ in definition, resolution, period of acquisition, method of observation and processing data
- WEED wetland extend in the range of uncertainty of observation data except for the equatorial latitudes (evaporation and routing problems, but perhaps satellite does not see all the wetlands due to huge treetops?)
- JSBACH-ESA reduces wetland extend in comparison with JSBACH-WEED, but also in comparison with ESA-CCI WB product, probably due to incomplete lateral flow
- cooling due to increased ET physically consistent, warming and increased runoff calls for change in runoff formulation
- no significant improvements of biases and annual cycles