Universiteit Utrecht

Faculty of Geosciences

The Residence Time of Water in the Atmosphere and Contrasting Roles of Interception and Transpiration

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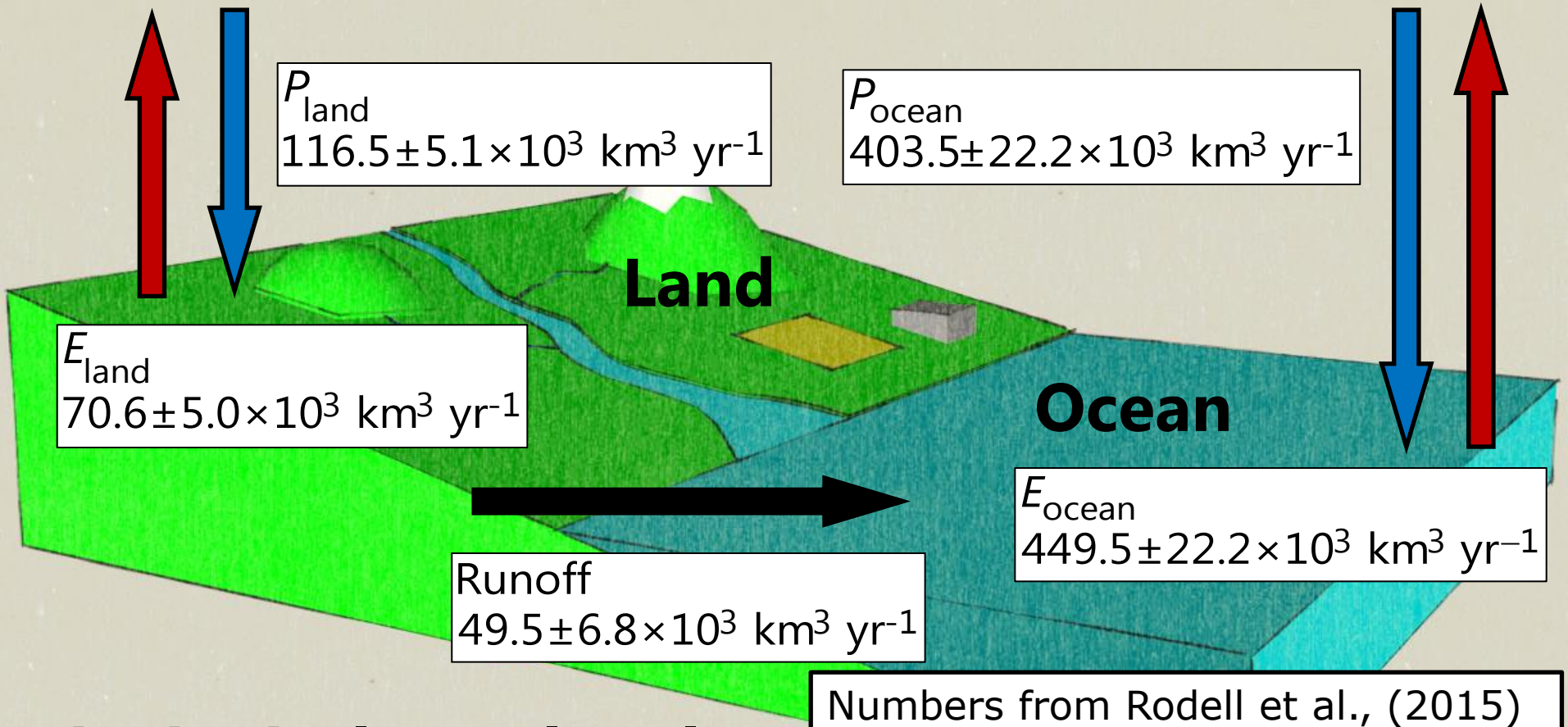
What is the residence time of water in the atmosphere?

Atmosphere

Storage
$12.6 \pm 0.2 \times 10^3$ km^3

Residence Time =
Storage / Flux =
12.6 / 520 = 0.024 years
=
8.9 ± 0.4 **days**

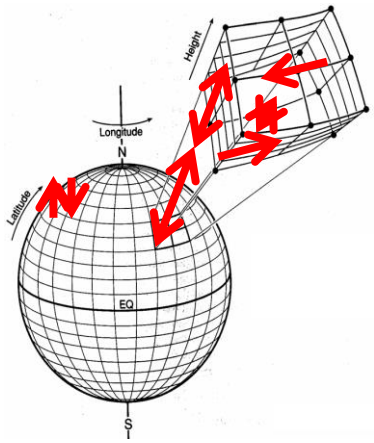


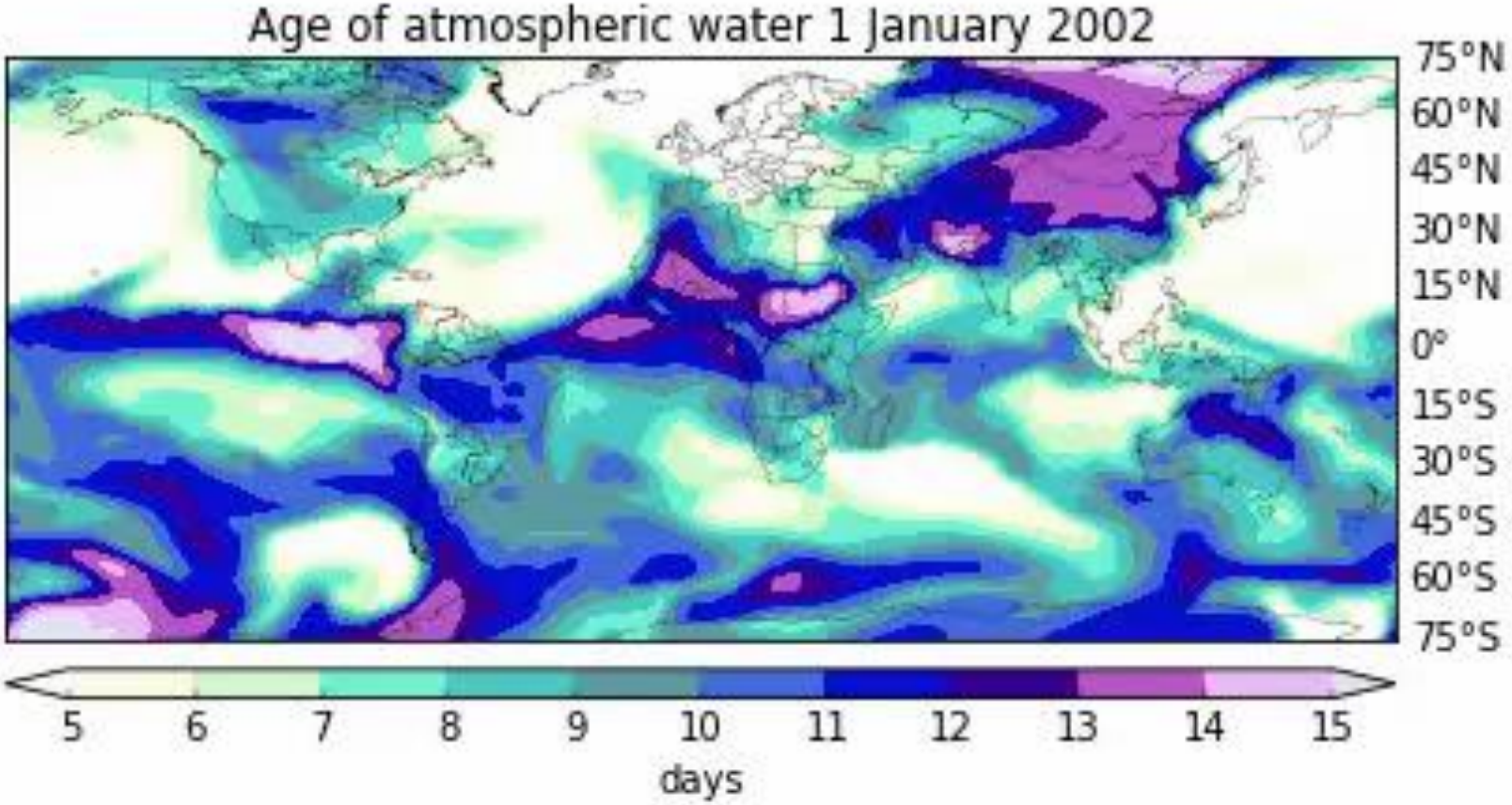
The hydrological cycle

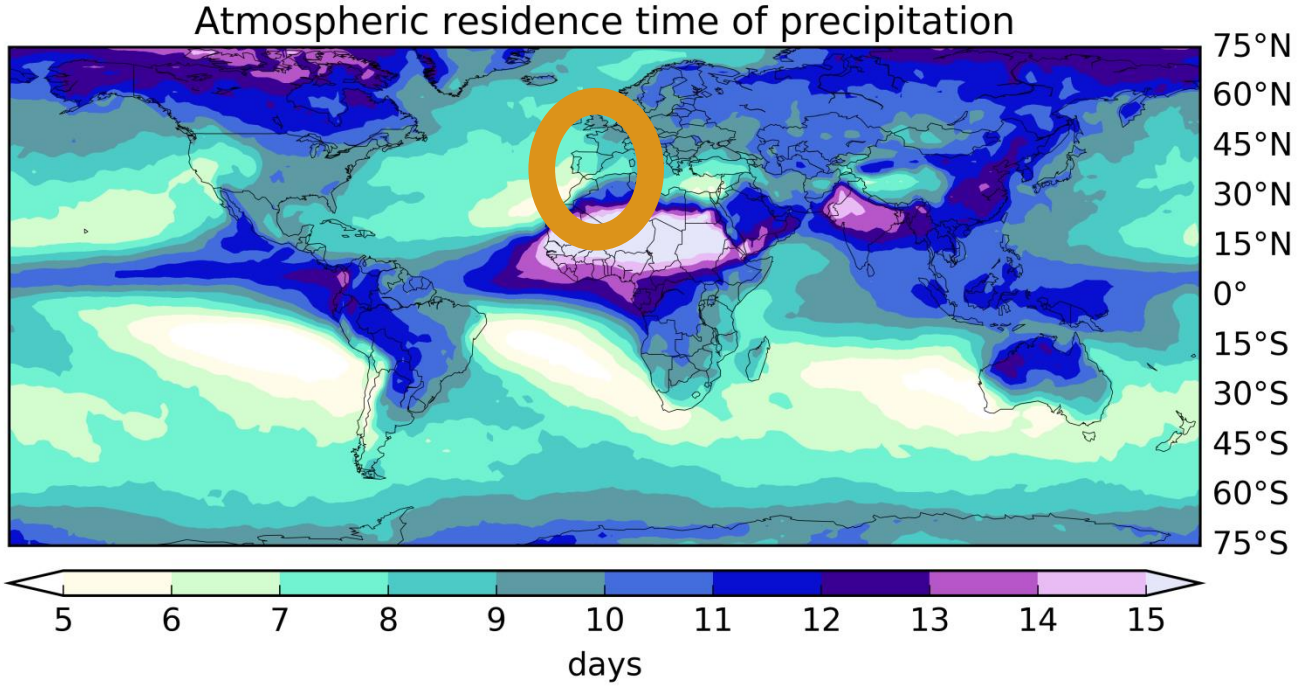
Numbers from Rodell et al., (2015) and Trenberth et al., (2011). In: van der Ent and Tuinenburg (2016)

Spatial variability of residence time?

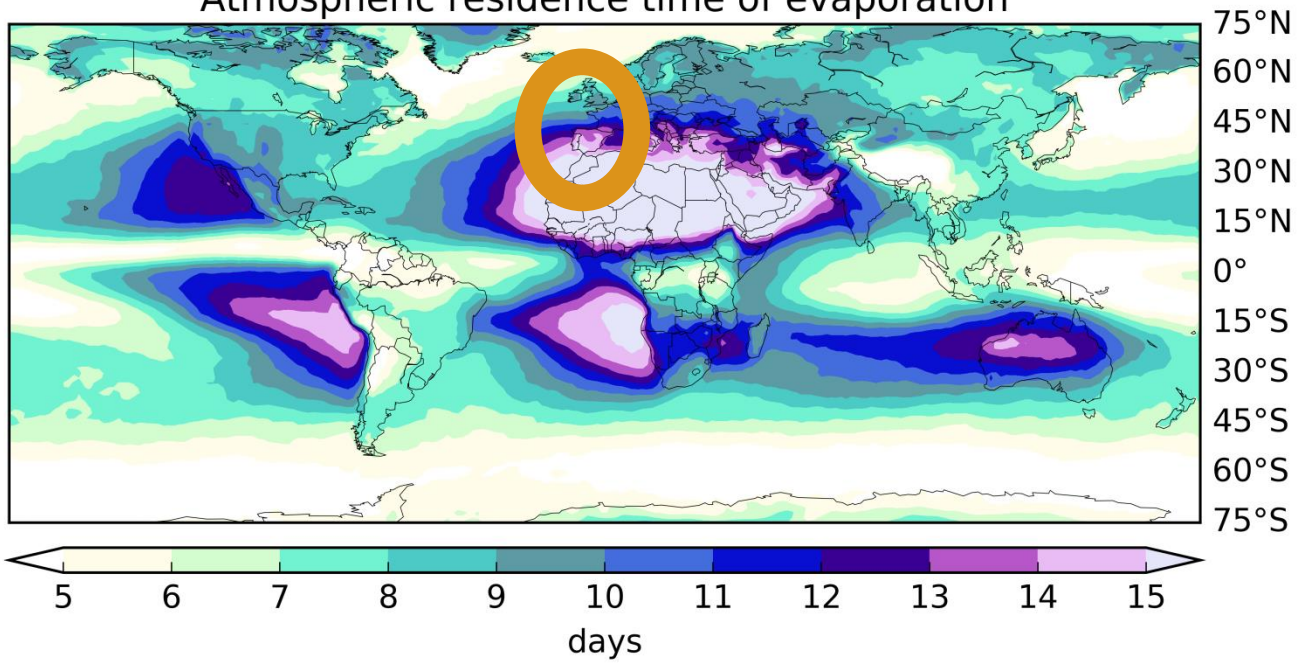
- Two moisture tracking methods (van der Ent et al., 2013)
  - WAM-2layers (Van der Ent, 2014)
    - Eulerian (explicit accounting age of tracked moisture)
  - 3D-Trajectories (Tuinenburg, 2012; Dirmeyer and Brubaker, 1999)
    - Lagrangian (mass change of water parcels in time)
- ERA-Interim reanalysis (Dee et al, 2011)
  - Precipitation
  - Evaporation
  - Specific humidity (models levels)
  - Wind speeds
  - Surface pressure
- Forward and backward tracking (15min. timestep)



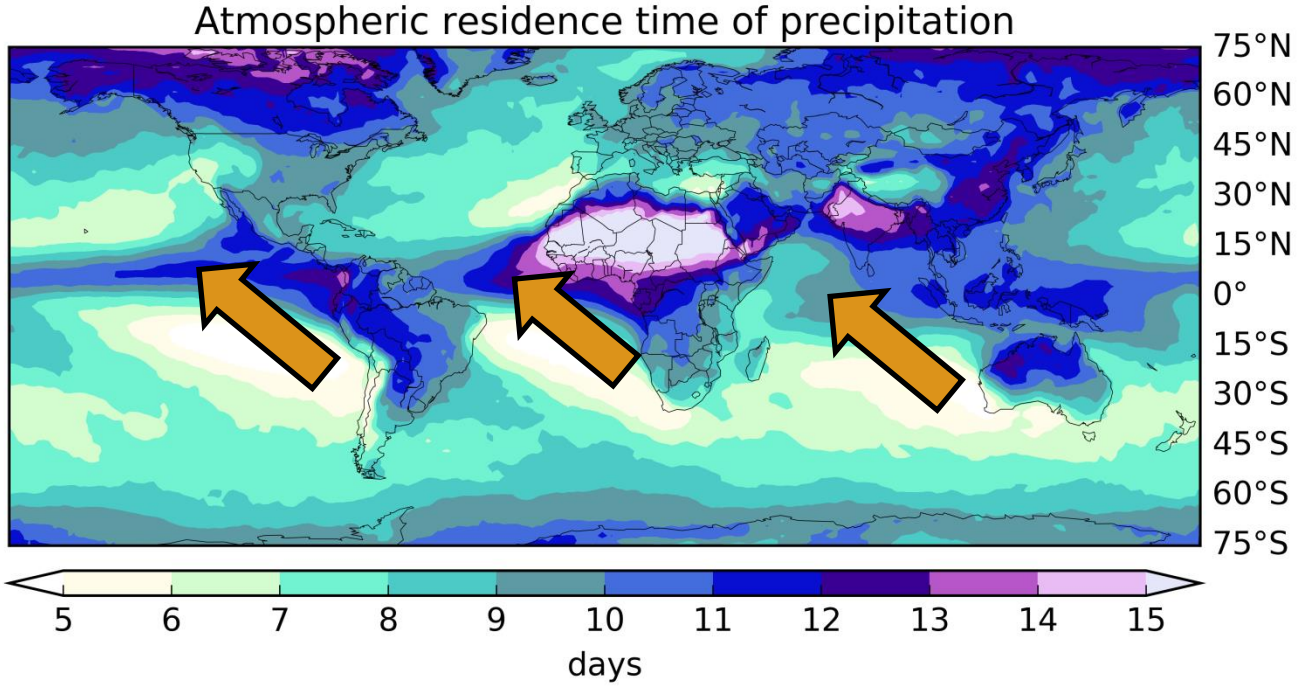

Age of atmospheric water 1 January 2002
75°N
60°N
45°N
30°N
15°N
0°
15°S
30°S
45°S
60°S
75°S
5
6
7
8
9
10
11
12
13
14
15
days

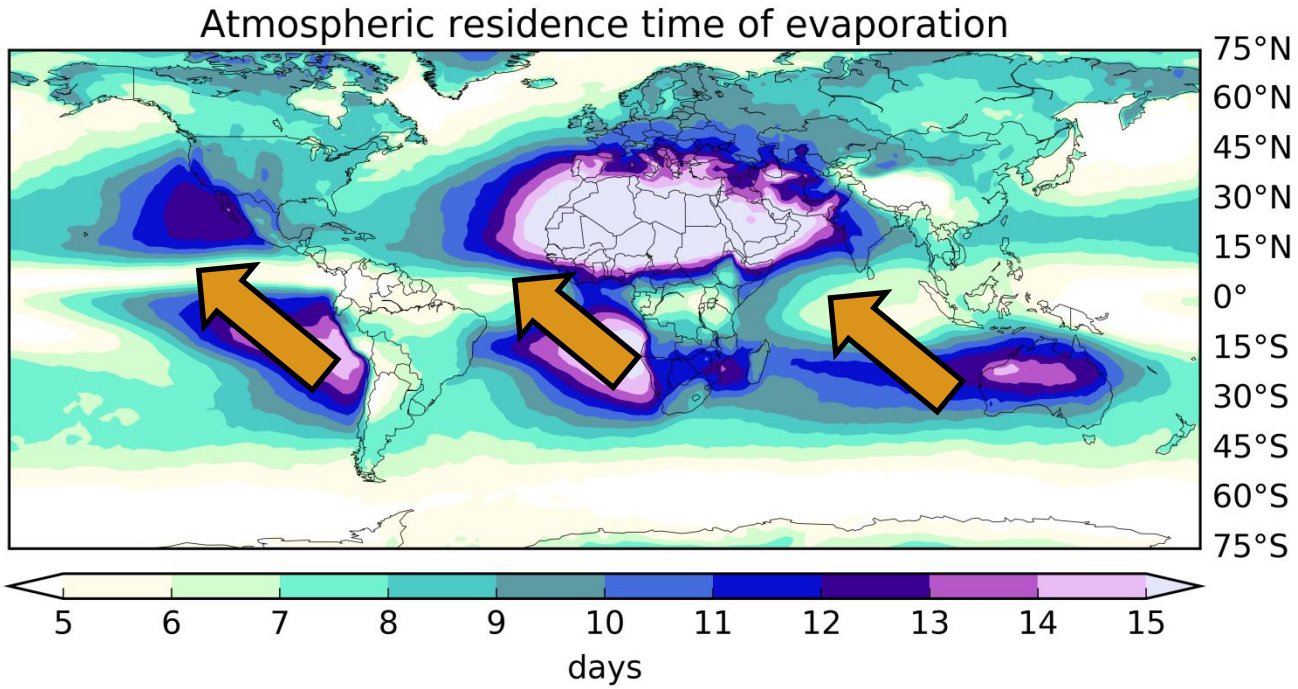


Average time water **has spend** in the atmosphere at the **moment** it **precipitates**

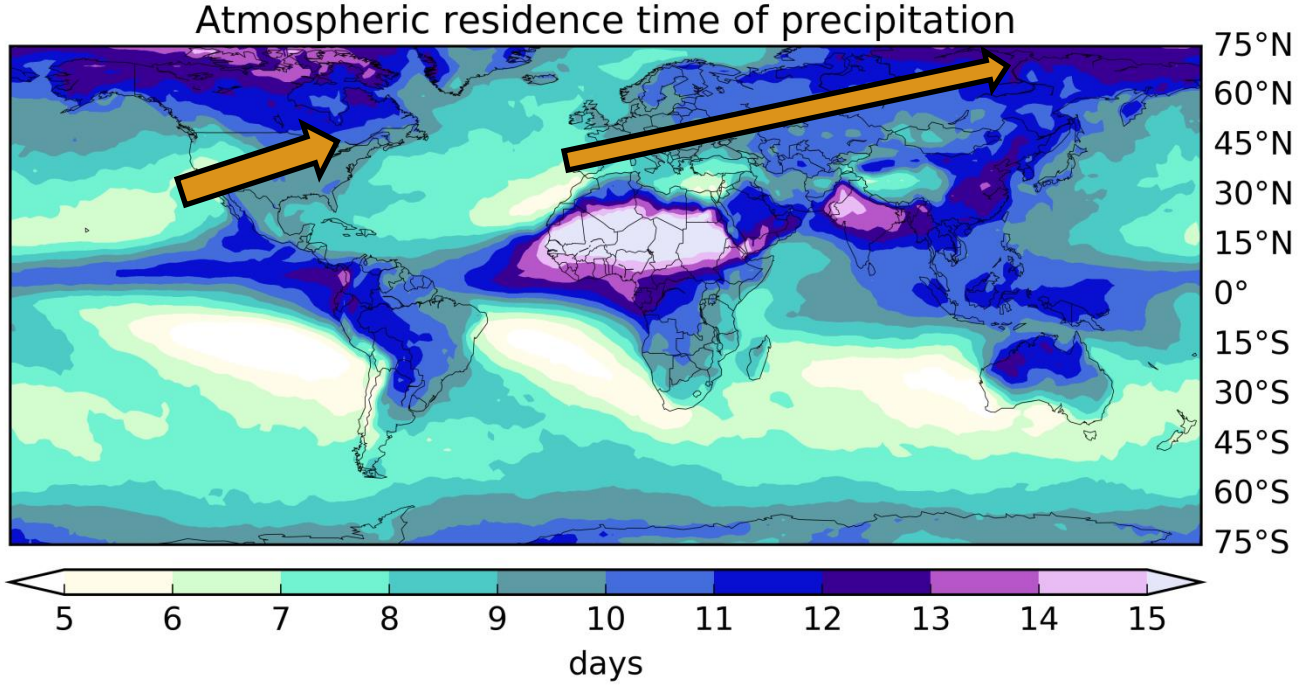


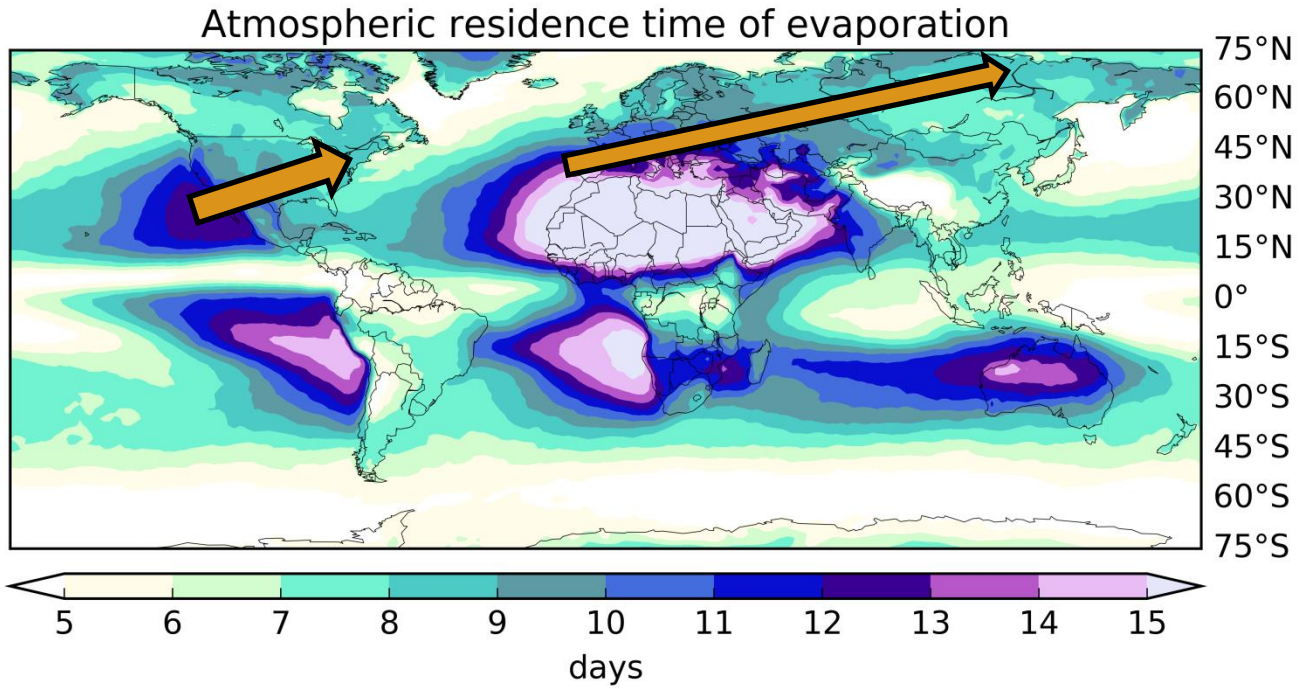
Average time water **will spend** in the atmosphere before at the **moment** it **evaporates**



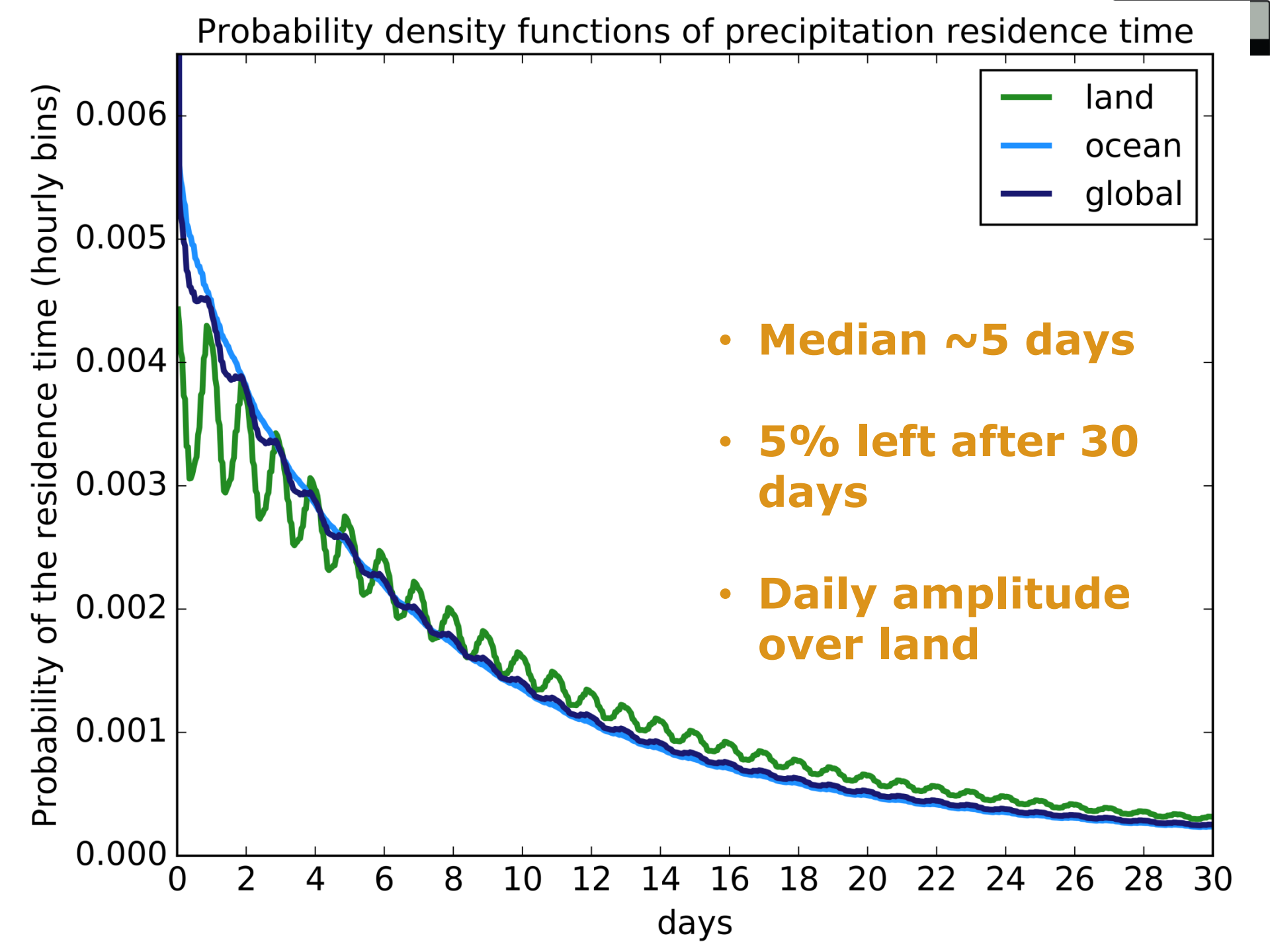


High oceanic evaporation toward the ITCZ





Opposite gradient of residence time following water inland


Probability density functions of precipitation residence time
Probability of the residence time (hourly bins)
0.006
0.005
0.004
0.003
0.002
0.001
0.000
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
days
land
ocean
global
• Median ~5 days
• 5% left after 30 days
• Daily amplitude over land

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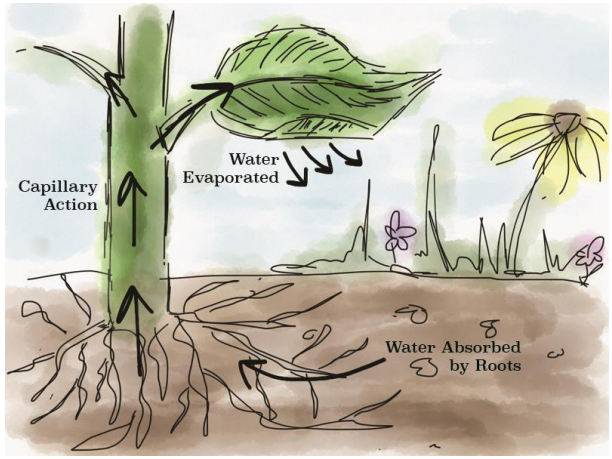
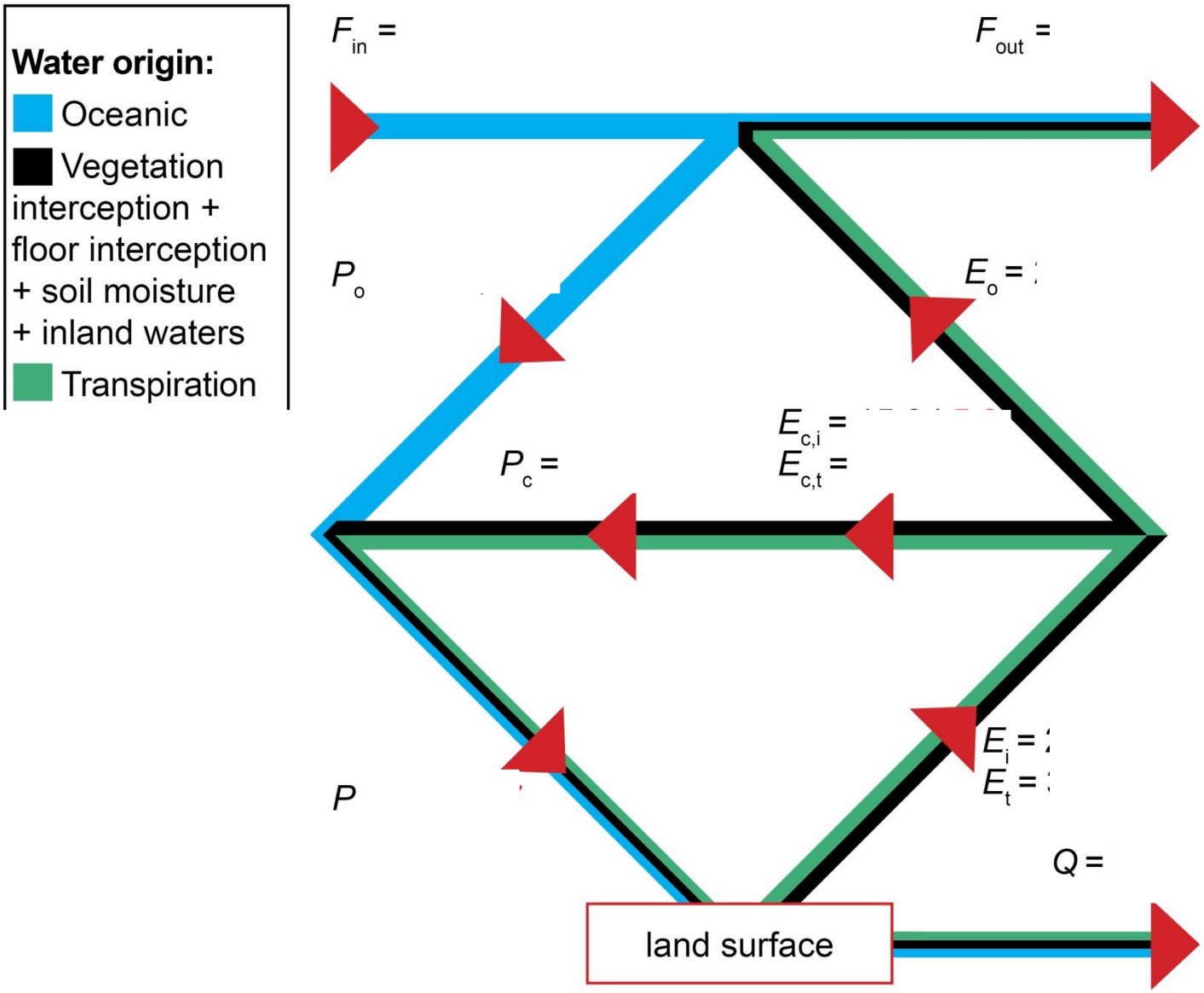
Do different land evaporation components have different atmospheric residence times?

Interception and soil evaporation

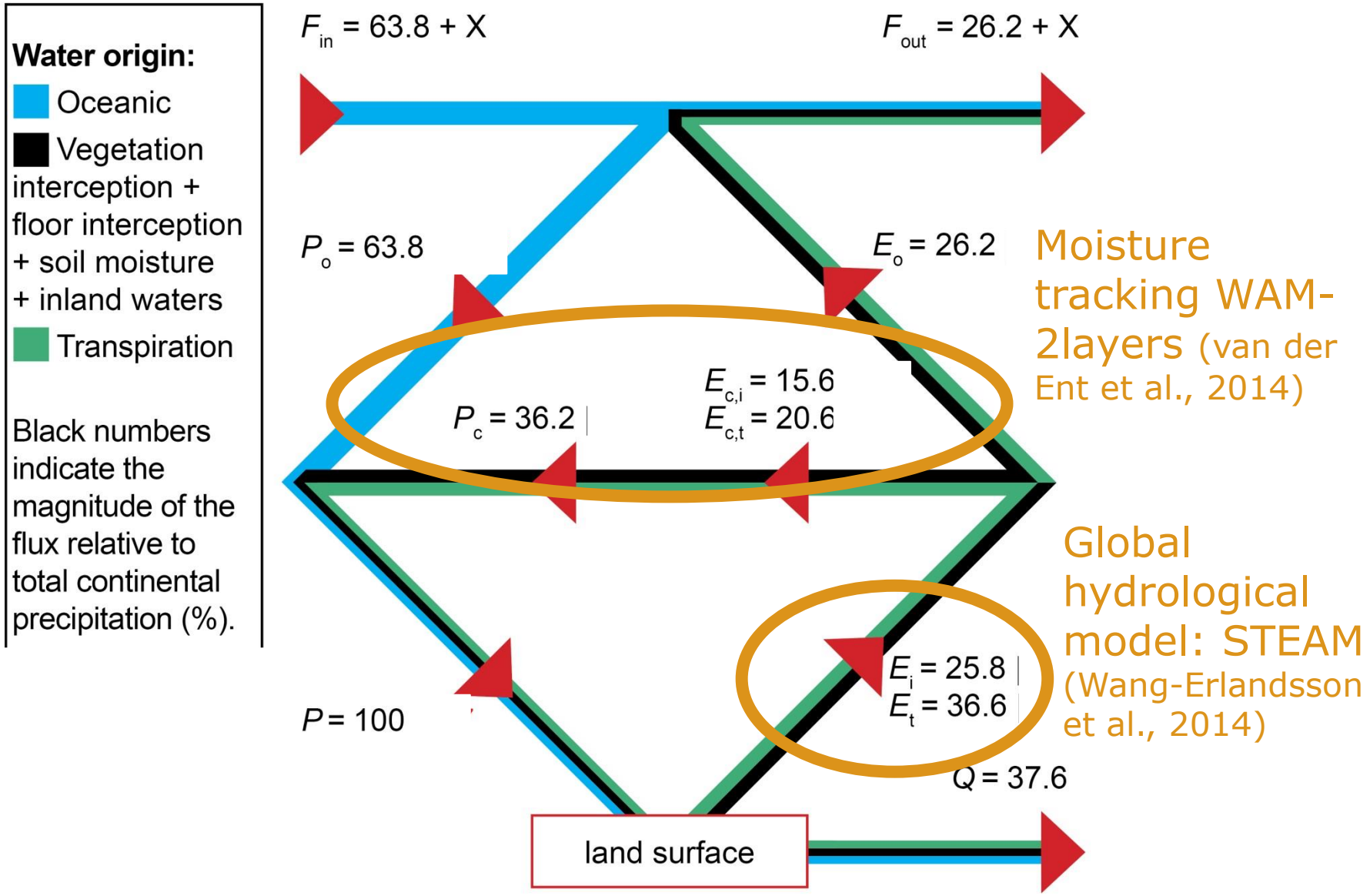


Transpiration

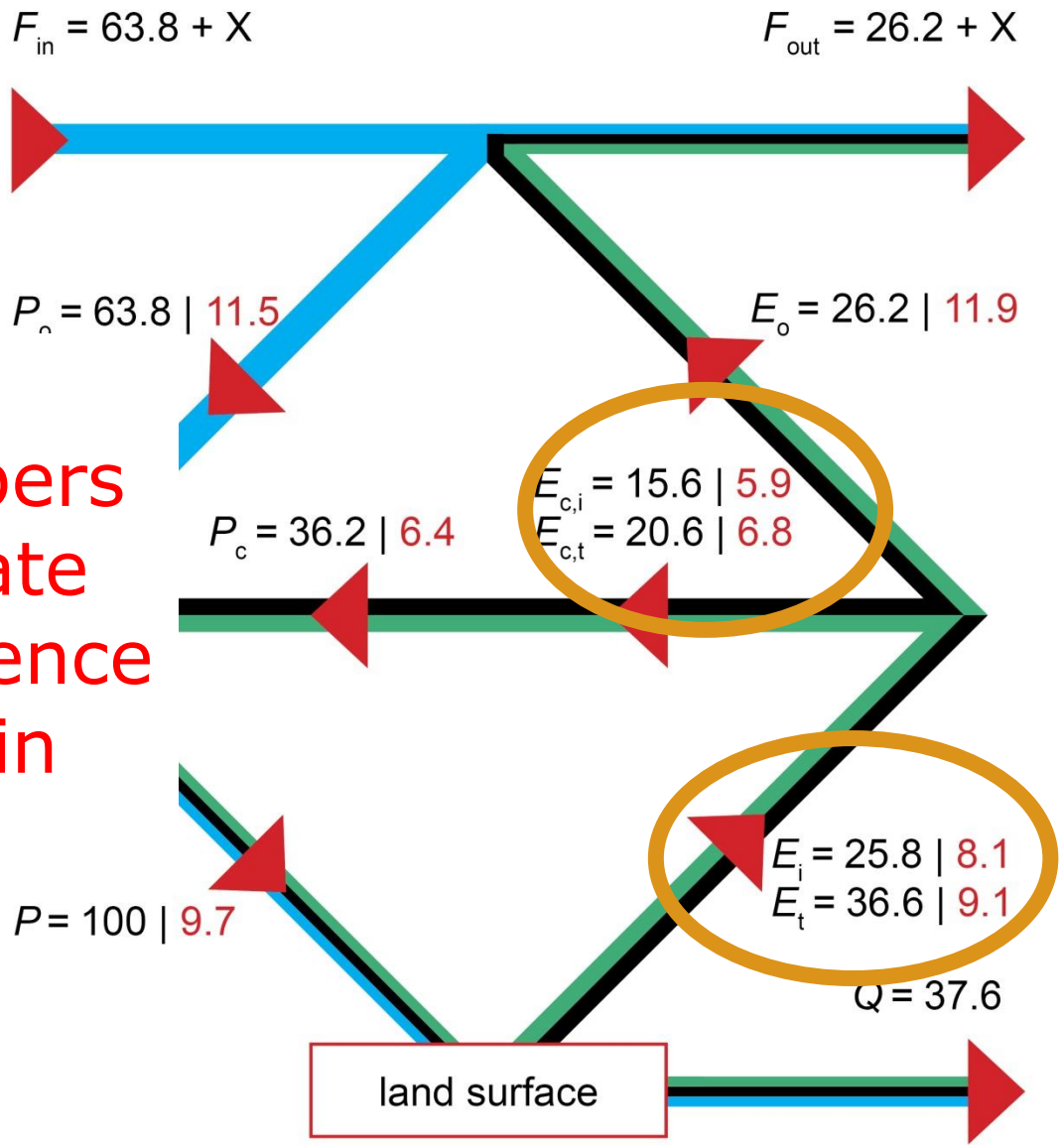
Continental hydrological cycle



Continental hydrological cycle



Continental hydrological cycle



Red numbers indicate residence time in days

- Residence time of **recycling** on land is **2 days lower** than average
- Residence time of **interception** **1 day lower** than **transpiration**

Take home messages

- Global average **residence time** of water in the atmosphere is **8–10 days**
(based on global water balance)

- **Different ways** to look at residence time: **precipitation** weighted, **evaporation** weighted or actual **age** of water particle

- **Long tail** in probability density functions of residence time (global **median ~ 5 days**)

- **Interception** has a **~1 day lower** residence time than **transpiration**

Thank you!

Further reading:

- van der Ent, R. J. and Tuinenburg, O. A.: **The residence time of water in the atmosphere revisited**, *Hydrol. Earth Syst. Sci. Discuss.*, doi:10.5194/hess-2016-431, in review, 2016.
- van der Ent, R. J., Wang-Erlandsson, L., Keys, P. W., and Savenije, H. H. G.: **Contrasting roles of interception and transpiration in the hydrological cycle – Part 2: Moisture recycling**, *Earth Syst. Dynam.*, 5, 471-489, doi:10.5194/esd-5-471-2014, 2014.