Update on JULES soil moisture stress JPEG

JULES annual meeting, 14 September 2021
Anna Harper, Karina Williams and the JPEG team
Summary of updates

• Paper in GMD
• Group discussions
• Recommendations for Global Land (GL) configuration
• Next steps
GMD paper

- Evaluated JULES GPP and LE at 40 sites from u-al752
- Focused on 11 sites with 10 different representations of soil moisture stress ($\beta$)
- Improvements in GPP with deeper soils (10.8m and 14 layers) and:
  - Soil matric potential replaces volumetric water content in the $\beta$ equation
  - Reducing threshold in soil moisture where stress begins
  - More access to deeper soil layers
- High bias in LE made worse with these changes, but seasonal cycle and variance was improved.
Recommendation 1: Deeper soils

- 3 layer --> 14 layer soil
- Max depth increased from 3 meters to 10.8 meters

Effective rooting profiles due to changes in soil depth and $d_r$

Harper & Williams et al. 2021
Recommendation 2: delay onset of stress to drier soils

- Non-zero $p_0$ agrees more with observations from Verhoef and Egea (2014).
OR
Recommendation 3: Use soil matric potential in stress equation

Default JULES uses θ (volumetric water content, m$^3$ m$^{-3}$):

$$\beta_k = \begin{cases} 
1 & \theta_k \geq \theta_{upp,k} \\
\frac{\theta_k - \theta_{wilt,k}}{\theta_{upp,k} - \theta_{wilt,k}} & \theta_{wilt,k} \leq \theta_k \leq \theta_{upp,k} \\
0 & \theta_k \leq \theta_{wilt,k}
\end{cases}$$

Note: $\theta_{upp} = \theta_{crit}$ in default JULES

‘psi’ approach uses soil matric potential (MPa):

$$\beta_{\psi,k} = \frac{\psi_k - \psi_{close}}{\psi_{open} - \psi_{close}}$$

Potential for PFT-dependent $\psi_{open}$ and $\psi_{close}$ ($\psi_{close}$ can be approximated by turgor loss point)

Harper & Williams et al. 2021
GPP evaluation

- Based on simulations with most prescribed data available (SM or SM+LAI)
- Four categories:
  - Simulated GPP was too low but not because of stress
  - Simulated GPP was too high
  - Simulated GPP was too low and removing stress improved the simulation
  - As above but other processes are also missing

Harper & Williams et al. 2021
Impacts of different $\beta$ experiments

- All these experiments were an improvement over the default except ‘p0’ with 4-layer soil
- On average the best results were with soil14_p0 and soil14_psi (lowest RMSE, variance ratio closest to 1, highest $r$)

Harper & Williams et al. 2021

9 more sites evaluated in the paper!
Sites for further evaluation

- LBA-K67: JULES GPP is low during dry season → Missing impact of seasonal leaf flushing (e.g. Wu et al. 2016)?
- RU-Che: GPP too low during growing season due to dry soils → overactive evaporation or sublimation?
- CA-Oas: 2001, 2002 and 2003 were drought years but in 2001 stored soil moisture led to high GPP. GPP was low in 2002 and 2003. 2004 was interesting because even with high precip the stand hadn’t recovered so GPP remained low → lag effects of precip anomalies

Harper & Williams et al. 2021
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Group talks and discussions


Recommendations for GL configuration

• Work in progress: Impacts of deeper soil, more soil layers on global simulations

• Checking for unexpected side effects of different combinations of options (ie TOP model on/off; 20 layers extend to 7.9m (used in Eleanor Burke and Sarah Chadburn’s permafrost configuration)

Changes in GPP due to different assumptions about Ks changes with depth, access of roots to deep soil moisture, number of layers and soil depth
Next steps

• What have we accomplished over 5 years and where do we want this group to go?
  • Lots of useful discussions
  • supporting student and post-doc work
  • sharing of Fluxnet rose suite
  • Recommendations for GL configuration

• Other issues have been highlighted through our work:
  • Bare soil evaporation is overestimated
  • We can only get so far with a beta parameterization of soil moisture stress, modeling soil/plant hydraulics (SOX) is important for future development

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