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Climate impacts on the water balance of rainforests in northern Queensland, Australia

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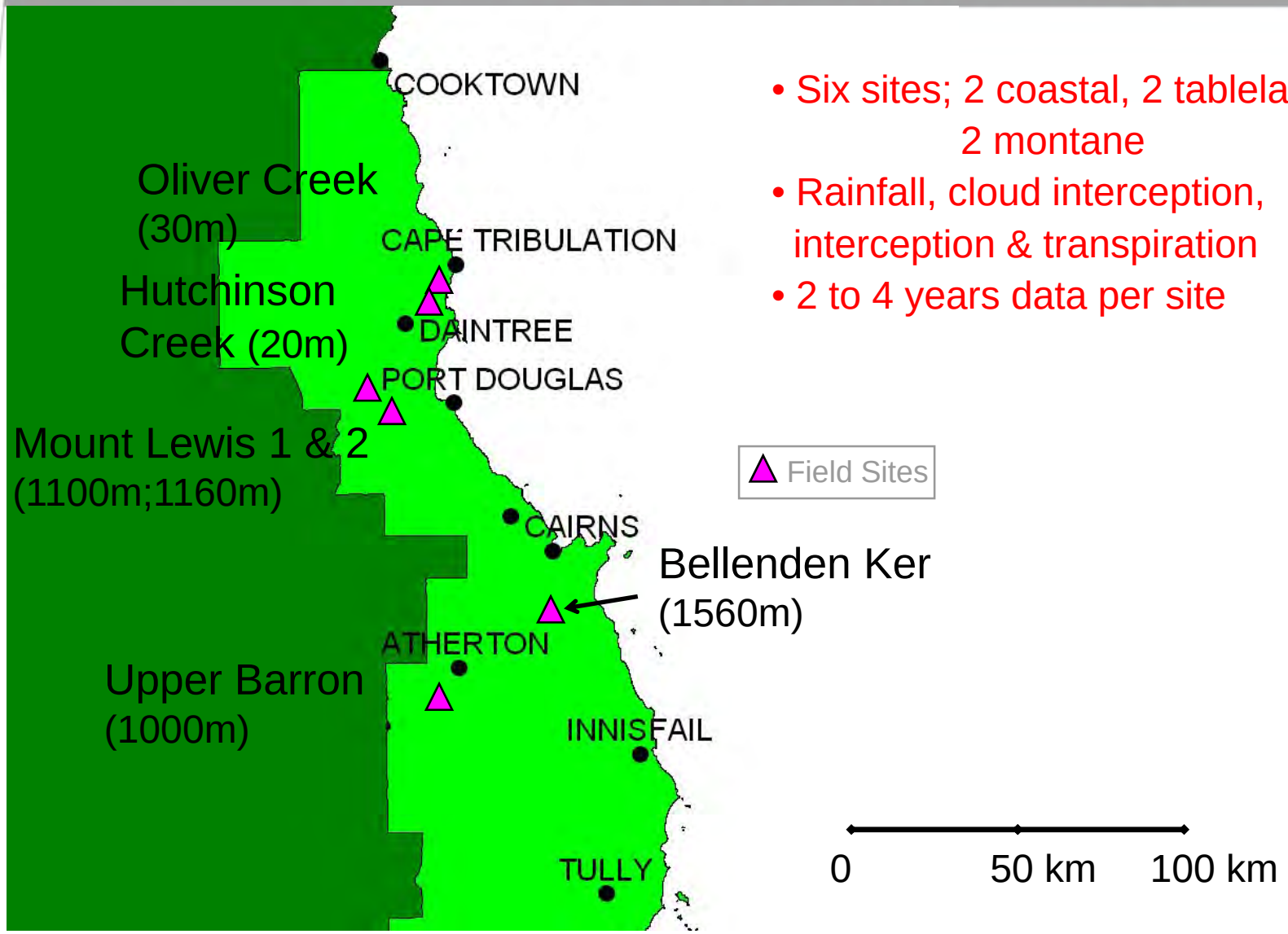
Outline

- **Water balance of Australian rainforest catchments**
  - Rainforest locations and measurement techniques
  - Water balance of different rainforest types
- **Climate change scenarios for northeast Queensland**
- **Effects of changes in climate**
  - How will the rainforest water balance change under future climate?
  - What are the downstream impacts on river flows, especially in the dry season?

Rainforest water balance sites

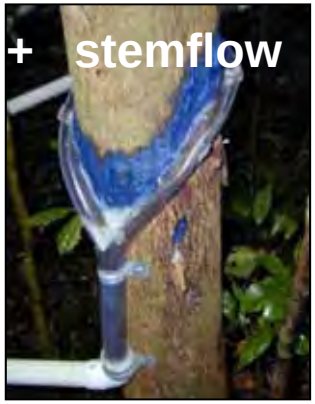


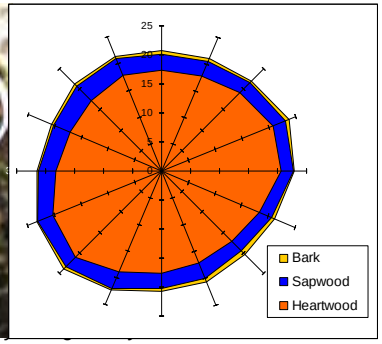
- Six sites; 2 coastal, 2 tablelands, 2 montane
- Rainfall, cloud interception, interception & transpiration
- 2 to 4 years data per site

Measurements: Rainfall, cloud interception, interception loss & transpiration

Cloud interception gauge

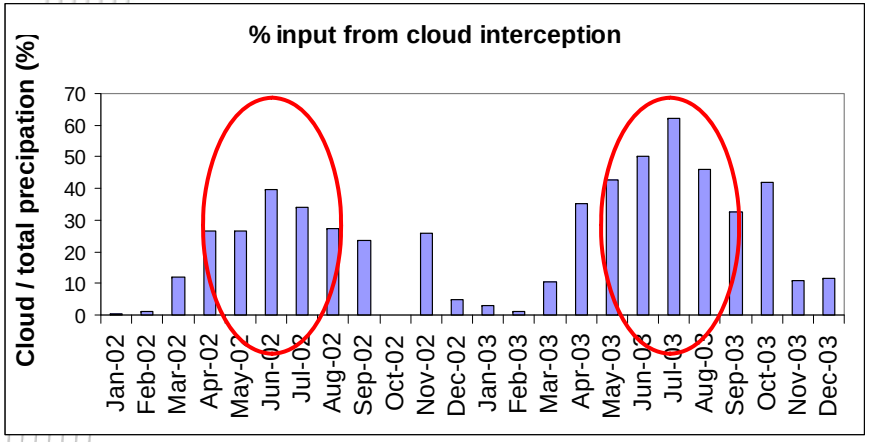
Rainfall interception = rainfall - throughfall + stemflow



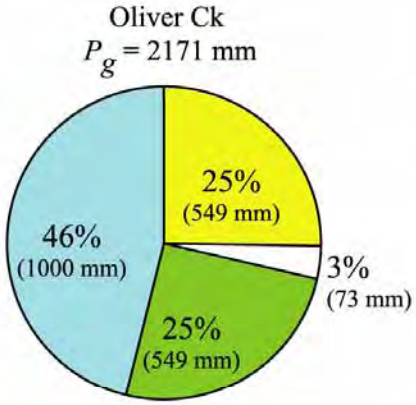


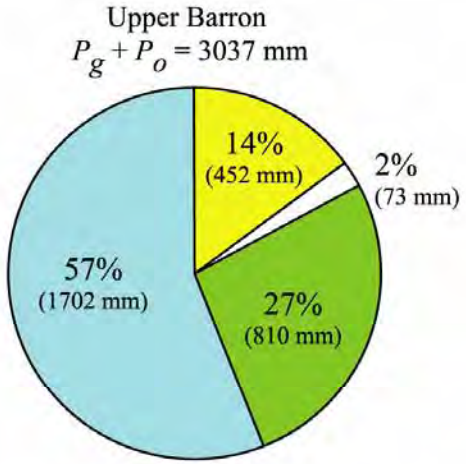
Transpiration – heat pulse method

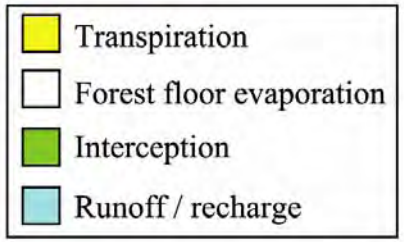
Rainforest water balance

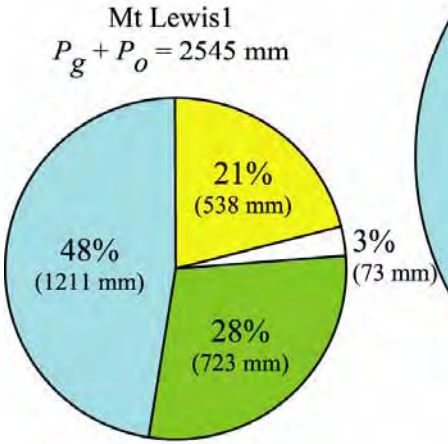


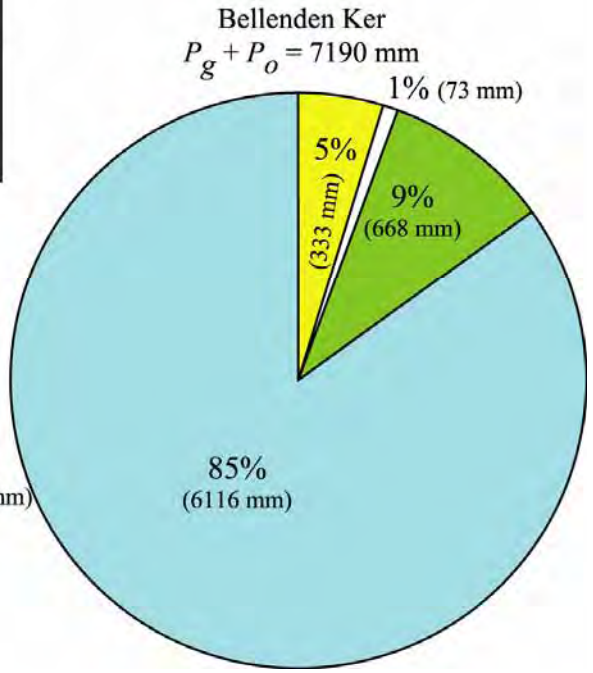
- **Cloud interception very important:**
  - **Annually; extra 7 – 29%**
  - **Dry season; 40-65% of total input**
- **Rainfall interception loss very high**
  - **25 – 28% coastal & lower montane**
  - **5% upper montane**
- **Transpiration is low *cf* potential**
  - **No large trees, nutrients, evolution?**
- **Runoff**
  - **montane forests > coastal forests**
  - **important for downstream flow**









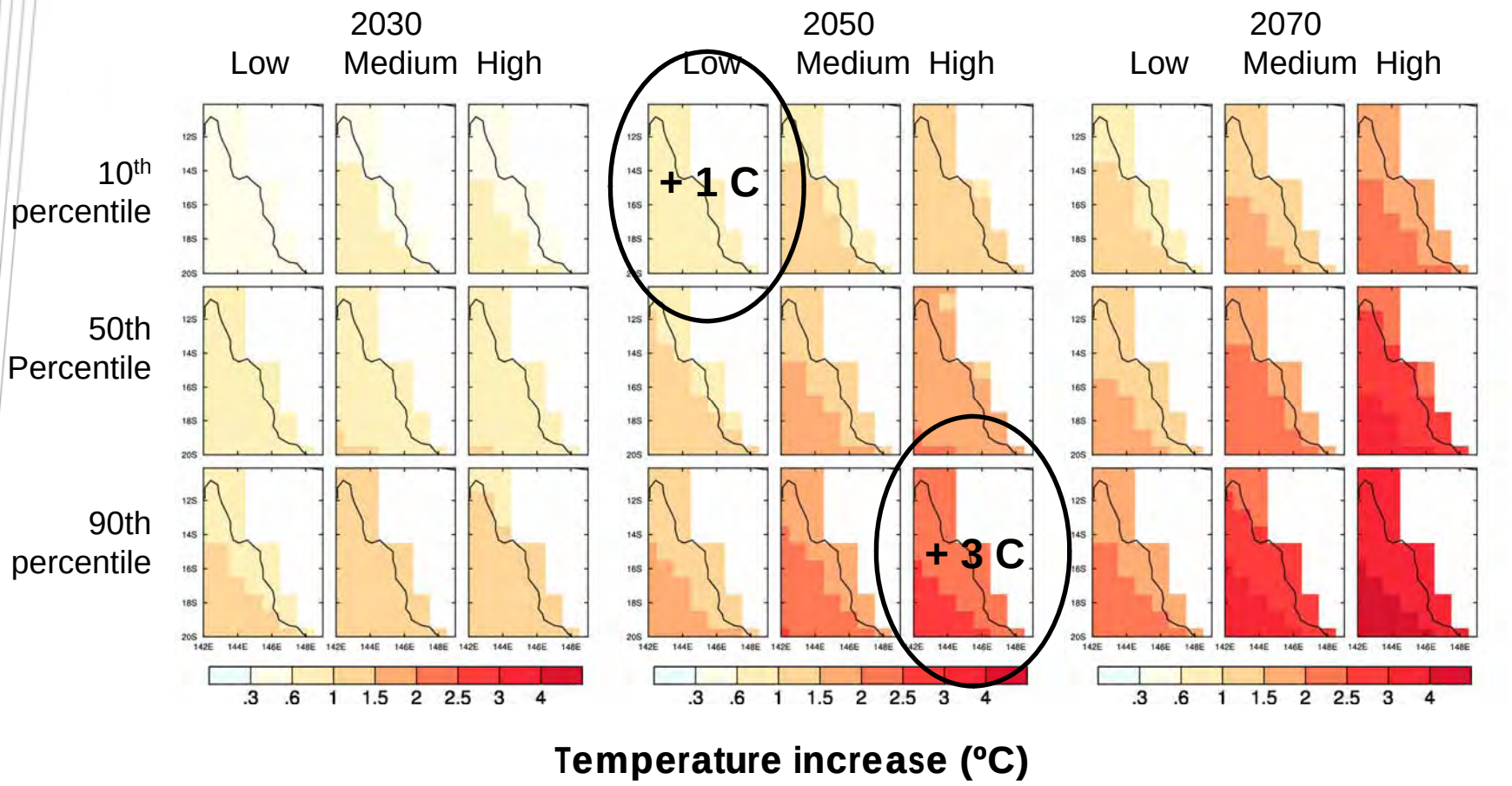


Climate impacts on downstream runoff

- **Precipitation – evaporation = ‘excess’ water left for runoff, drainage and soil moisture storage**
- **Used 66 year (1940-2006) daily rainfall, temperature, radiation and humidity record from Cape Tribulation to calculate evaporation from lowland coastal rainforest**
  - Evaporation = Interception + Transpiration + Soil evaporation
  - Interception calculated using Gash model
  - Transpiration calculated using Wallace & McJannet model
  - Soil evaporation assumed = 0.2 mm day^{-1}
- **Repeat calculations for regional climate changes in rainfall and temperature**

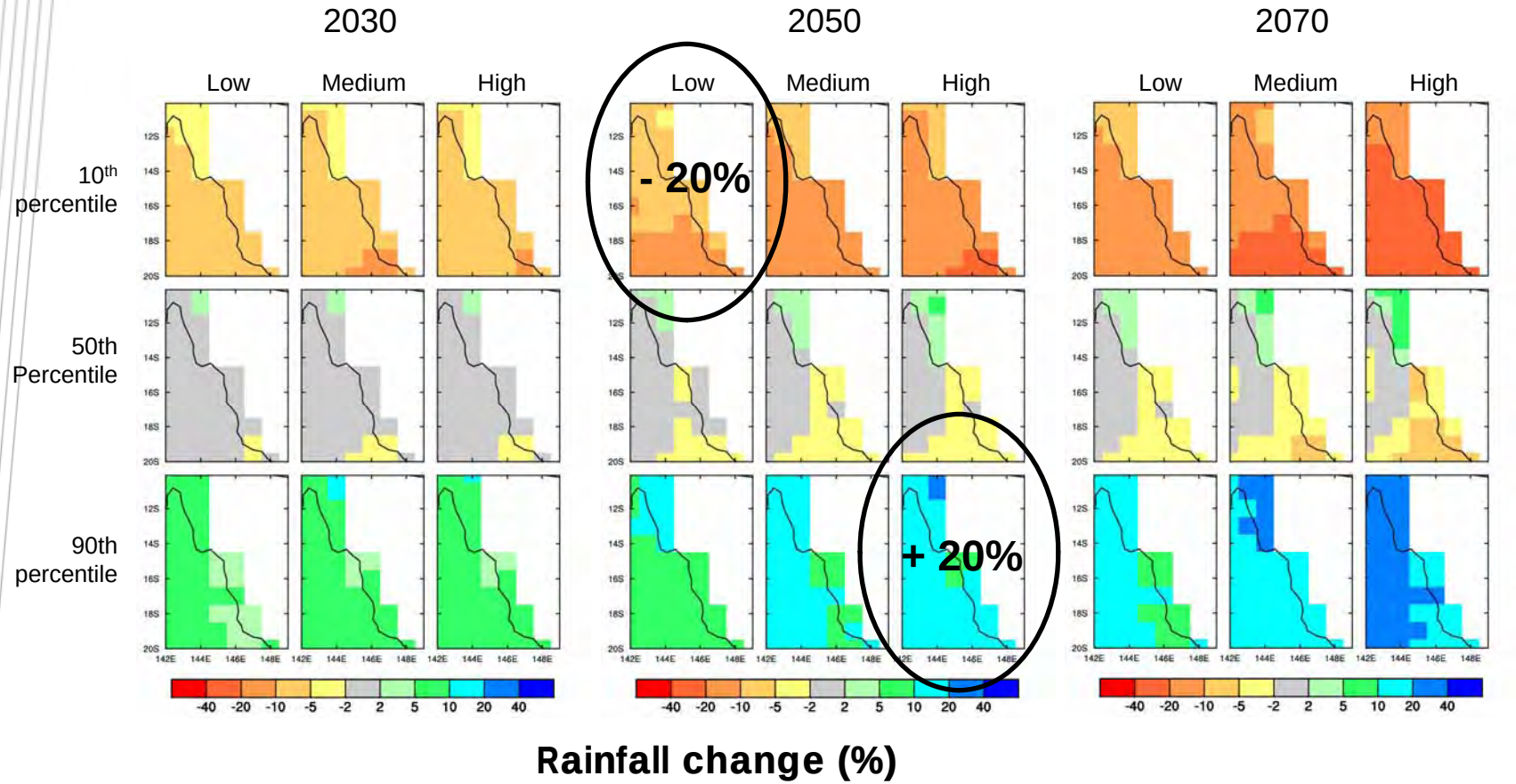
Climate change – temperature (Suppiah *et al*., 2010)

Projected 10th, 50th and 90th percentiles increases in annual temperature (ºC) for low, medium and high emission Scenarios for 2030, 2050 and 2070



Climate change – rainfall (Suppiah *et al*., 2010)

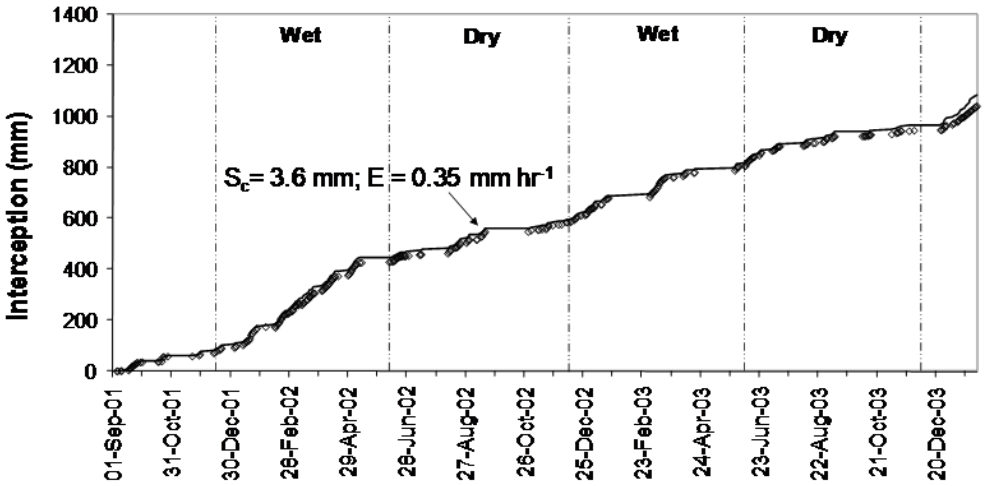
Projected 10th, 50th and 90th percentiles changes of annual rainfall (%) for low, medium and high emission scenarios for 2030, 2050 and 2070



Climate impacts – Interception

- **Interception – Gash model**

interception loss	Revised Gash analytical form
1. Small storms	$c\sum_{j=1}^{m} P_{ga,j}$
2. Wetting up the canopy	$ncP'_{ga} - ncS_c$
3. Evaporation during rain	$(cE_c / R)\sum_{j=1}^{n}(P_{ga,j} - P'_{ga})$
4. Evaporation after rain	ncS_c
5. Evaporation from trunks	$qS_t + p_t\sum_{j=1}^{n-q} P_{ga,j}$



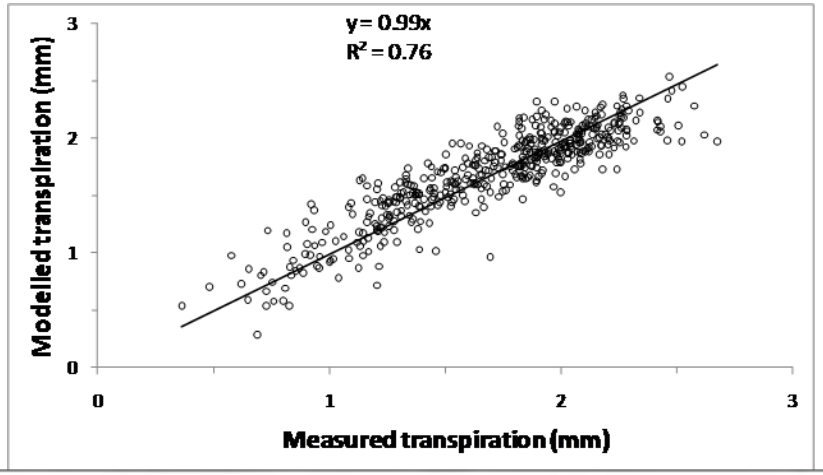
- Model accuracy ± 2 – 10% over long (month/year) periods
- Climate perturbations via *Pg (not, yet via R)*

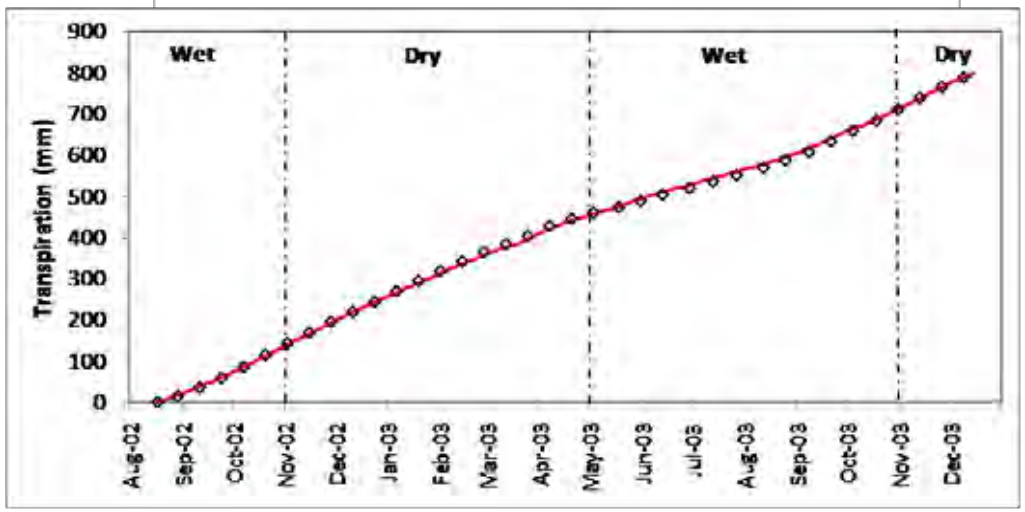
Climate impacts – transpiration

- **Transpiration – Wallace & McJannet (2009)* model**

$$E_t = a\ VPD^b\ S_t^c$$

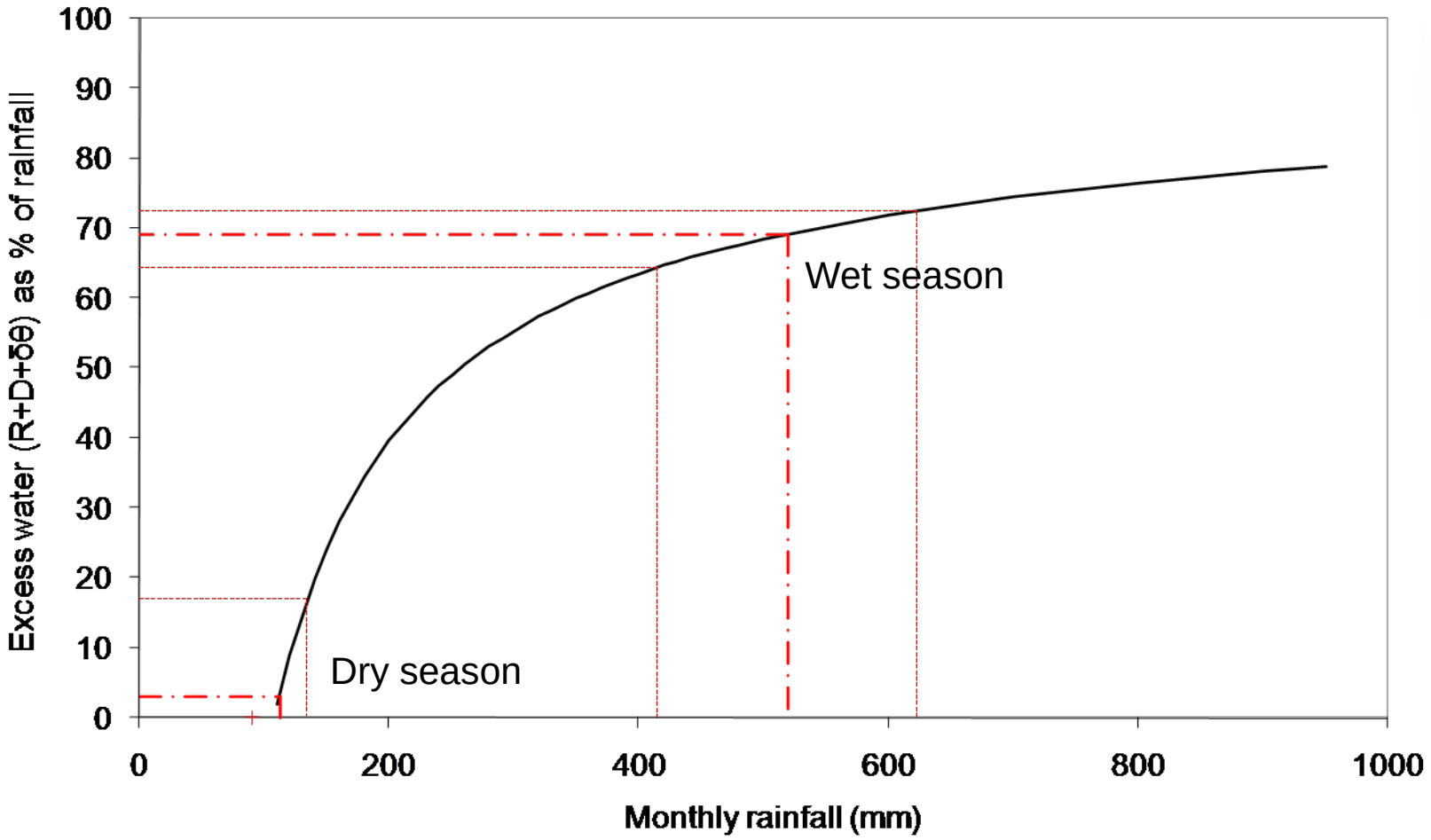
- Model accuracy ± 1 – 2% over long (month/year) periods
- Climate perturbations via temp effect on *VPD (not, yet via S_t)*
- Changes in E_t are small
  - *T + 1°C; ~ +3%*
  - *T + 3°C; ~ +9%*





*Wallace J.S. and McJannet D.L. 2010. Processes controlling transpiration in the rainforests of north Queensland, Australia. *Journal of Hydrology 384, 107-117.*

Climate impacts – Wet and Dry season flows



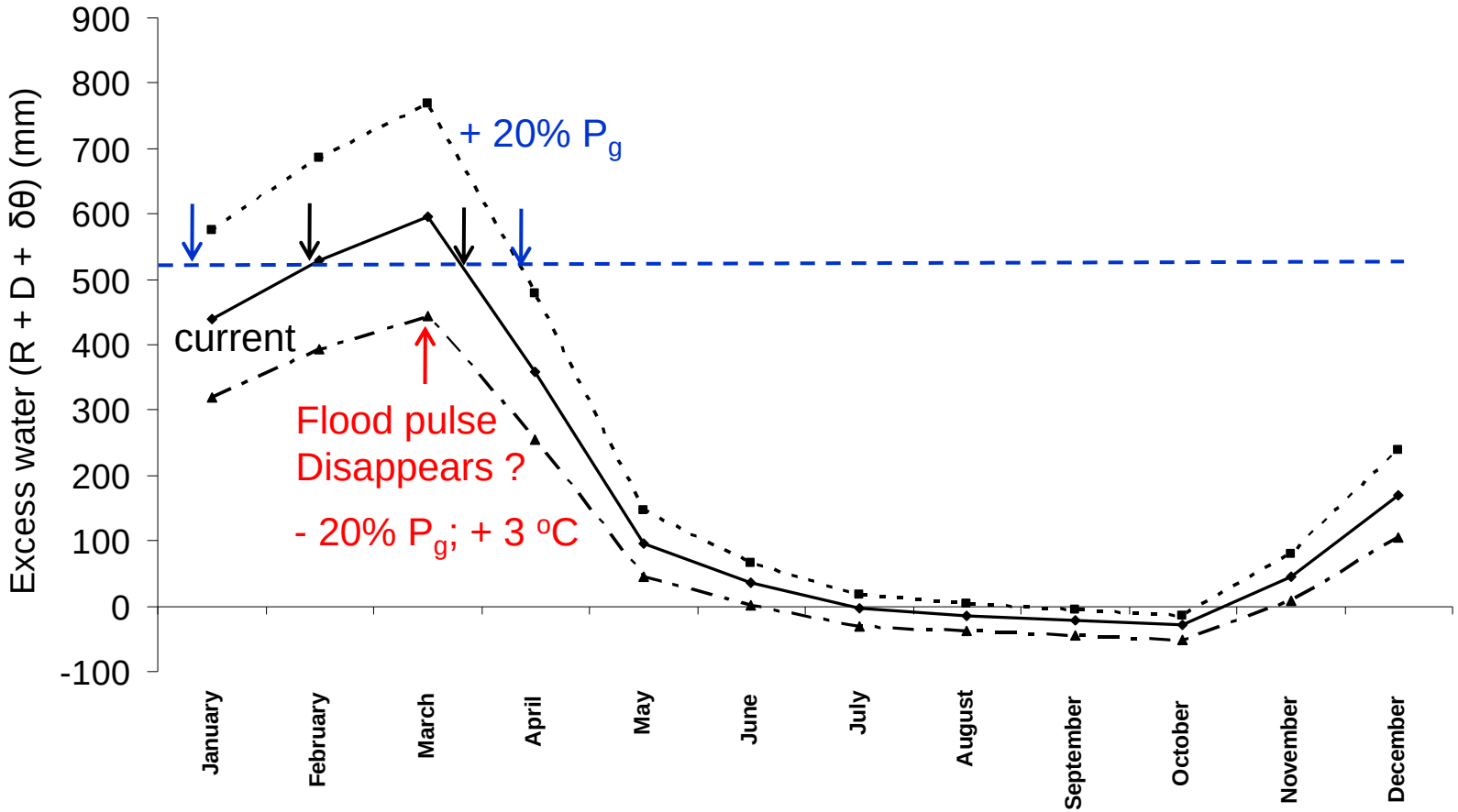
Wet season change in ($R + D + \delta\theta$) = ± 30%; Dry season change in ($R + D + \delta\theta$) = ± 90%

Climate impacts – on Wet season flows

1. Current - flood risk period, e.g. ~ 2 months

2. + 20% P_g – flood risk period may ~ double

3. - 20% P_g; + 3 ^oC Flood pulse may become rare / disappear

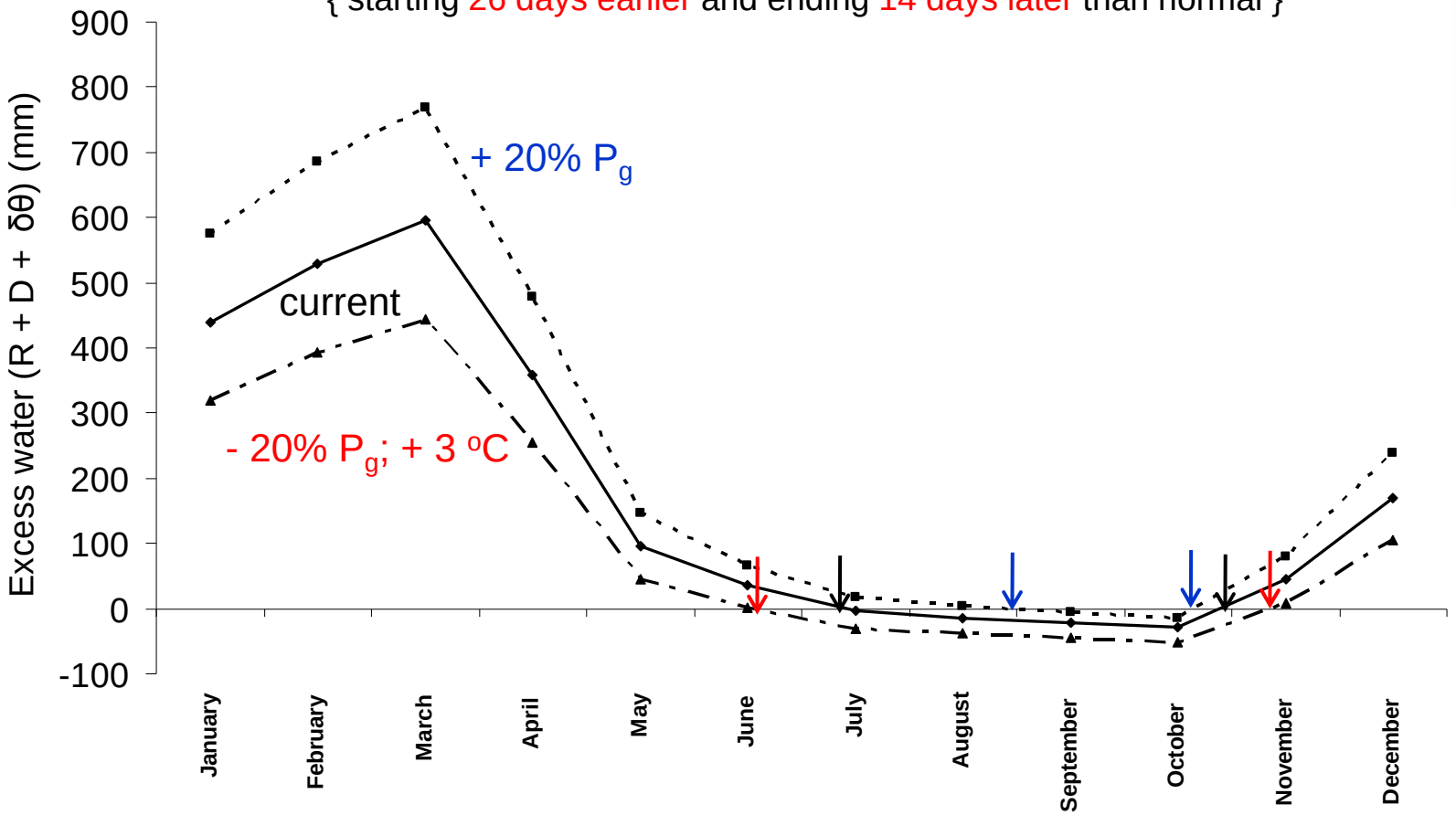


Climate impacts – on Dry season flows

1. Current - zero excess water period is 108 days

2. + 20% P_g – zero excess water decreases by 53 days

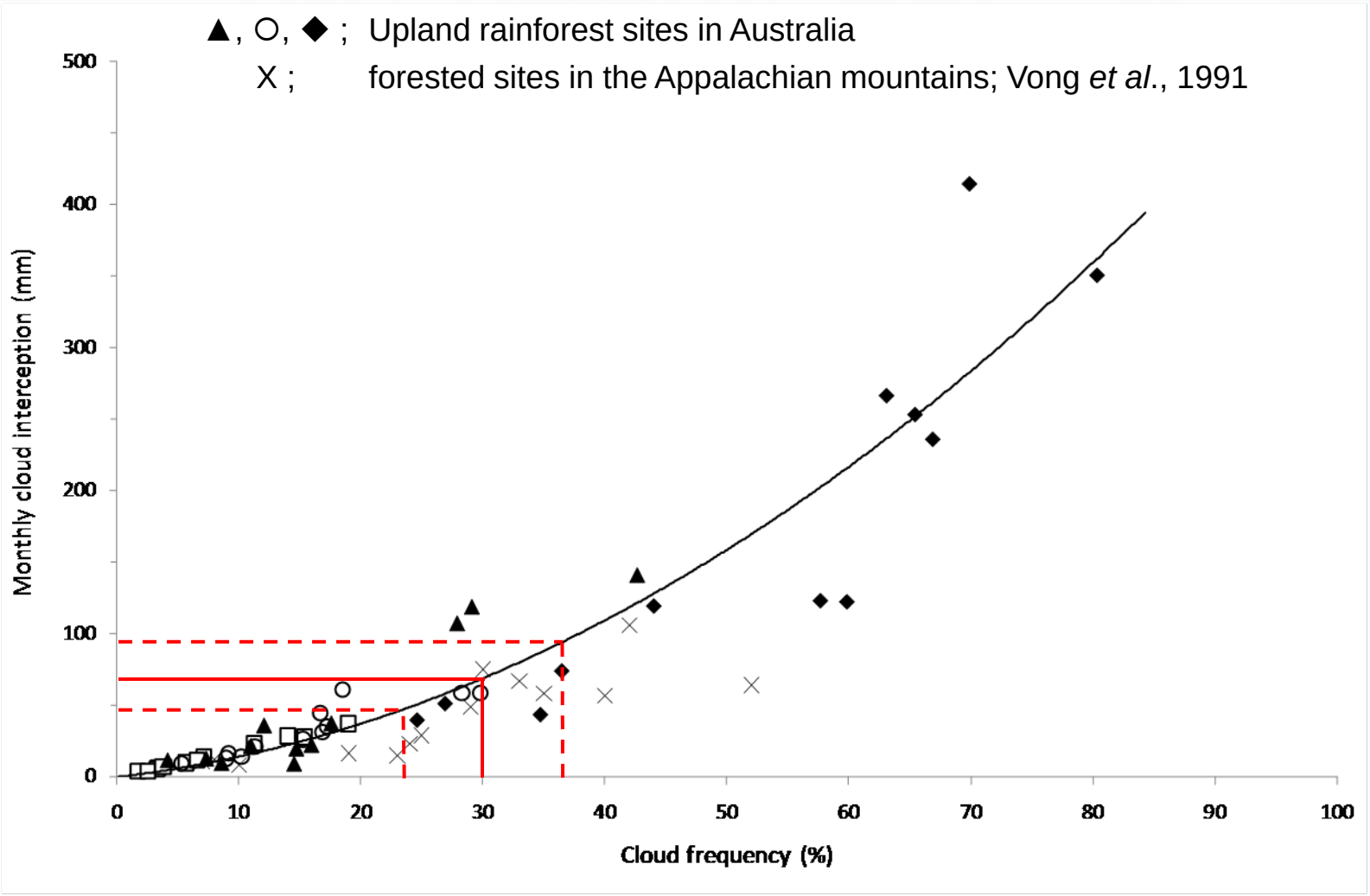
3. - 20% P_g; + 3 ^oC - zero excess water increases by 40 days,
{ starting 26 days earlier and ending 14 days later than normal }



Climate impacts – cloud interception

▲, ○, ◆ ; Upland rainforest sites in Australia

X ; forested sites in the Appalachian mountains; Vong *et al*., 1991



± 20% change in cloud frequency gives a ~ 30% change in cloud interception

Climate impacts summary

- Whatever the % change in rainfall; there is a greater % change in runoff

  ‘amplification’ increases as rainfall decreases

- Wet season flows; may alter flood size, frequency & duration

  {*impacting water supply, flooding & ecology*}

- Dry season flows; very sensitive and could disappear

  duration of no excess water; large change & timing alters

  {*start more sensitive than end -*

  may affect ecological triggers?}

- Cloud interception; any reduction in cloud cloudiness may reduce or remove an ecologically important water input {*especially in dry season*}

Further details in:

- WALLACE, J.S. and McJANNET, D.L. 2010. Processes controlling transpiration in the rainforests of north Queensland, Australia. *Journal of Hydrology* 384, 107-117.
- McJANNET, D.L. 2008. Water table and transpiration dynamics in a seasonally inundated *Melaleuca quinquenervia* forest, north Queensland, Australia. *Hydrological Processes*, 22, 3079-3090.
- WALLACE, J.S. and McJANNET, D.L. 2008. Modelling interception in coastal and montane rainforests in northern Queensland, Australia. *Journal of Hydrology* 348, 480-495.
- McJANNET, D.L., FITCH, P., DISHER, M. and WALLACE, J.S. 2007a. Measurements of transpiration in four tropical rainforest types of north Queensland, Australia. *Hydrological Processes* 21, 3549-3564.
- McJANNET, D.L., WALLACE, J.S., FITCH, P., DISHER, M. and REDDELL, P. 2007b. Water balance of tropical rainforests in north Queensland, Australia. *Hydrological Processes* 21, 3473-3484.
- WALLACE, J.S. and McJANNET, D.L. 2006. On interception modelling of a lowland coastal rainforest in northern Queensland, Australia. *Journal of Hydrology* 329, 477-488.
- McJANNET, D.L., WALLACE, J.S. and REDDELL, P. 2006a. Precipitation interception in Australian tropical rainforests: I. Measurement of stemflow, throughfall and cloud interception. *Hydrological Processes* 21, 1692-1702.
- McJANNET, D.L., WALLACE, J.S. and REDDELL, P. 2006b. Precipitation interception in Australian tropical rainforests: II. Altitudinal gradients of cloud interception, stemflow, throughfall and interception. *Hydrological Processes* 21, 1703-1718

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Thank you

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Climate impacts – canopy wetness duration

± 20% change in P_g gives a ± 10 – 15 % change in wetness duration