# Putting PUB in Practice – a Personal Perspective P5 !

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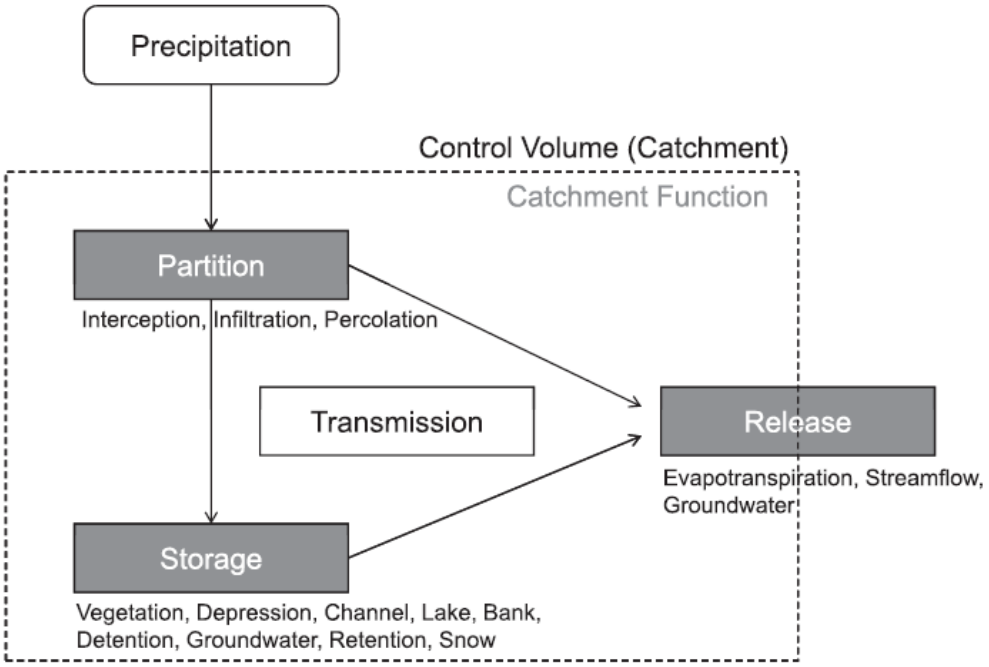
# What Does a Hydrological System Do?




- Function is different in different places
- If we want to do PUB using science, we need to know which place we are in, so we can use a relevant method
- This is why the ideas of classification and similarity are important for PUB

"Catchment function"
Wagener et al 2007, Geography Compass

# So many ways to Classify

- McNamara: “It’s about storage”
- Young: Storage is also in glaciers, lakes
- McDonnell & Woods (2004 J.Hydrol): ideas for classifying
  - the state in which water is predominantly stored: either frozen (snow and glaciers), or pore water (in soils, and rocks), or open water (lakes, wetlands, river channels);
  - The response time of the dominant catchment storage (volume of storage which has the largest flux, divided by the flux).

# Why Use Water State?

- **If water is in pores, it stays there if capillary and gravity forces are in balance**
- **If water is frozen, it remains frozen until energy transfers cause a change of state (to liquid or vapour)**
- **If water is in an open water body, it stays there unless topography permits water flow (or it evaporates or seeps)**



# Similarity Indices – Soil water

**Table 2. Dimensionless numbers for pore-water dominated hydrology at long time-scales (see**

| Dimensionless groups | | Dimensionless number | Interpretation |
|---|---|---|---|
| Climate | $E_p/P$ | Aridity index, R | Ratio of average demand for moisture to average supply of moisture |
| | $\lvert\delta_p - R\ \delta_E\rvert$ | Seasonality index, S | Amplitude of the seasonal cycle of precipitation minus potential evaporation |
| Canopy and soil | $w_{cm}/(P_\tau/N)$ | Canopy storage index, $W_c$ | Ratio of canopy storage to characteristic rainfall event depth |
| | $K/(P/N)$ | Relative infiltration, K | Ratio of characteristic infiltration rate to characteristic rainfall event rate |
| | $w_{rm}/P_\tau$ | Rootzone storage index, $W_r$ | Ratio of soil water storage capacity to annual rainfall |
| Saturated flow | $DL/(T_0 \tan\beta_r)$ | Advection response index, $t_0$ | Ratio of travel time for advective signal to duration of seasonal forcing |
| | $T_0 \tan\beta/LP$ | Relative transmissivity, $T_0$ | Ratio of maximum lateral outflow to characteristic water input rate |
| | – | Slope of topographic index distribution, $\omega$ | Rate at which saturated area expands |

(Wagener et al 2007 Geog. Compass)

(Kuchment & Gelfan, 2005)

$$\frac{K_s H_0}{D_0} = idem$$

- Peclet number

$$\frac{K_s T_0}{\theta_m H_0} = idem$$

- Free soil capacity

# Similarity - Snow

- Sturm classification: seasonal snowpacks in six classes, based on vegetation and meteorological conditions: tundra, taiga, alpine, prairie, maritime and ephemeral – rules available to implement this
- 4 similarity variables
  - Above freezing? $\bar{T}^* = \left(\bar{T} - T_0\right) / \left|\Delta_T\right|$
  - Summer precip? $\delta_P^* = \delta_P \, \mathrm{sgn}\left(\Delta_T\right) \cos\left(2\pi \, s_p / \tau\right)$
  - Deep snowpack? $\bar{P}^* = \bar{P} f_s\left(\bar{T}^*, \delta_P^*\right) / K \left|\Delta_T\right|$
  - Big T fluctuations? $\sigma_T^* = \sigma_T / \left|\Delta_T\right|$

(Woods 2009 Adv Wat Res)

# Similarity – Open water

- ? Help me out here!
- Slope of storage-discharge curves …
- Connectivity metrics

# Are Our Models Ready?

- Our conceptual models are simple enough that they are potential PUB tools for practitioners. But we aren't ready
  - parameters don't have good links to catchment characteristics
  - too time-consuming to get daily/hourly forcing data
- Several examples where the best-performing regionalisation technique for model parameters (usually of lumped conceptual models) is geographic proximity
  - "spatial proximity may be a better similarity measure for transposing catchment model parameters in space than physiographic catchment attributes" Merz and Bloeschl (2004)
  - Bad news for data-sparse PUB: we need breakthroughs to fix it
  - Make sure the model structure is not wrong, and the forcing & target data quality is ok, before starting calibration
  - Comparative analysis of catchments over many environments
- But I note the transfer of parameters reported by Pablo and Sacha

# Model Structure

- We haven’t heard much about selecting physically reasonable model structure(s) for an ungauged basin
- This is a significant source of uncertainty
- We seem to be focussing on parameter transfer, without realising that the model structure might be wrong
- We should be developing ways to estimate model structure in ungauged basins
  - pore-water / frozen-water / open-water classification?
  - similarity indices for process dominance?

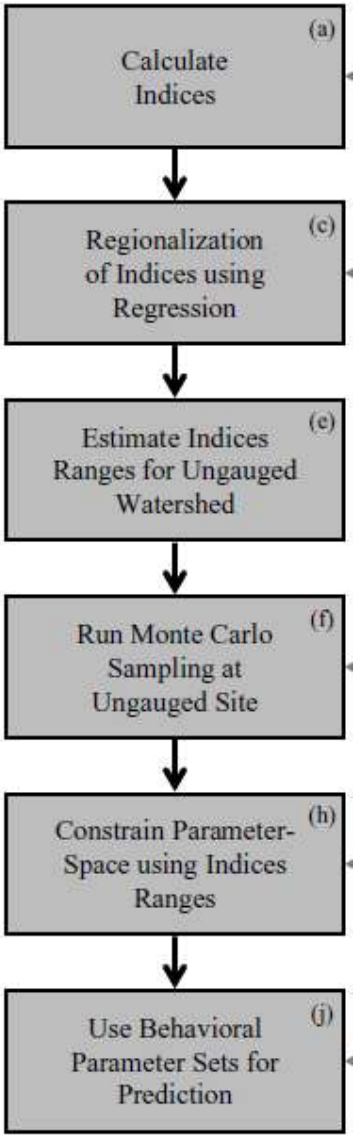
# A PUB Strategy for Precip-Runoff Modelling

- If you want to build a model for an ungauged basin, first make it a gauged basin!
  - Go sample the flows, and calibrate to that short series

  OR

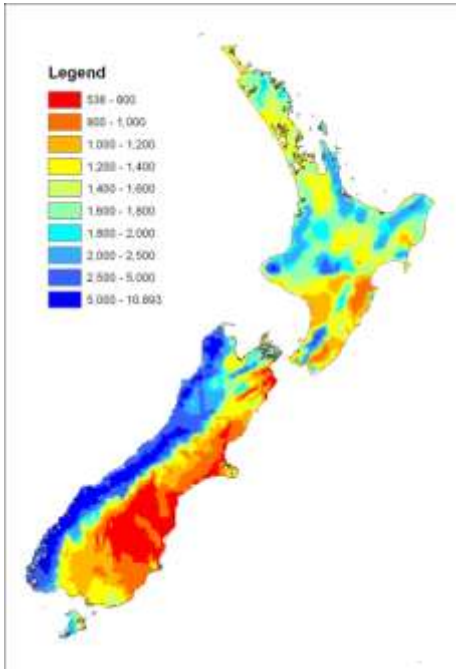
  - Regionalise flow statistics (mean, FDC, low-flow, monthly flow regime) and then calibrate your precip-runoff model so it adequately reproduces the regionalised stats (see Yadav et al, Adv.Wat.Res. 2007)

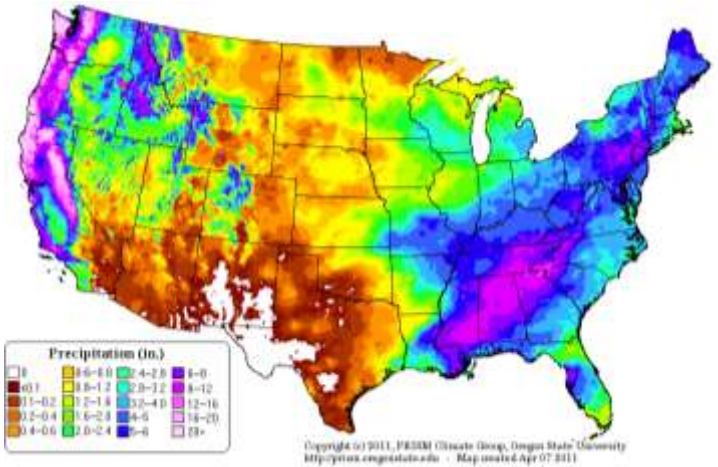
  OR …



# Practitioner's PUB Needs

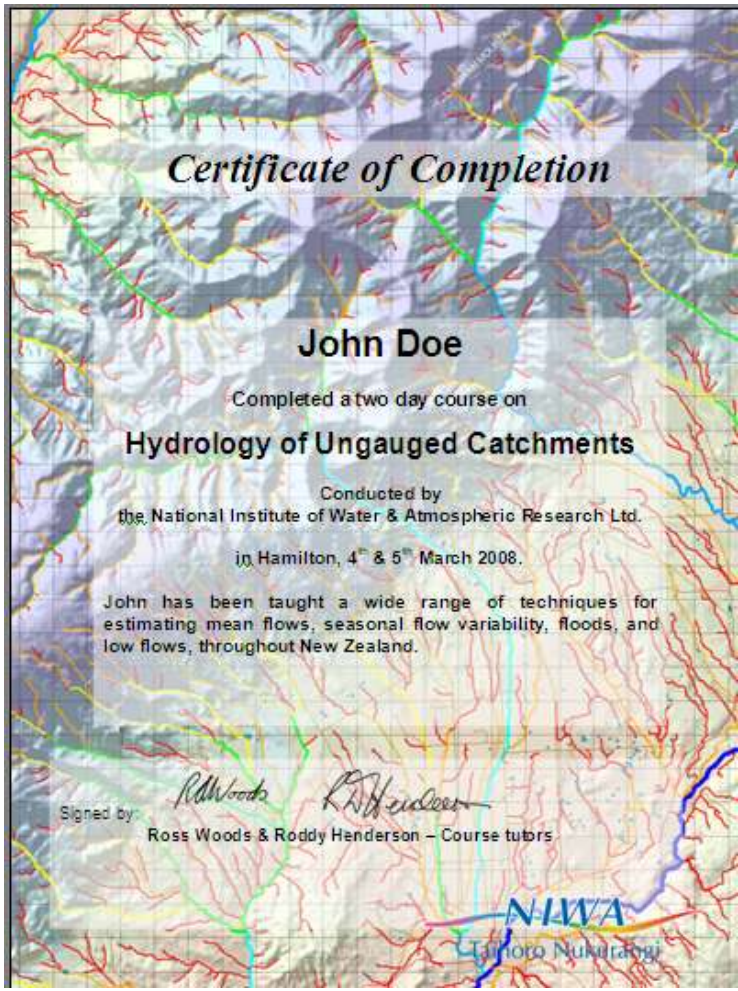
- Precipitation maps: crucial if there's no streamflow data
  - the #1 driver of hydrology
  - easier to map than streamflow
  - encourage and engage with your climate colleagues
  - make assessments of the reliability of numerical weather modelling of forcing data
  - a consistent "national" mapping product (e.g. PRISM) is a good start. It's never perfect, but is better than starting from nothing every time!



# Practitioner's PUB Needs

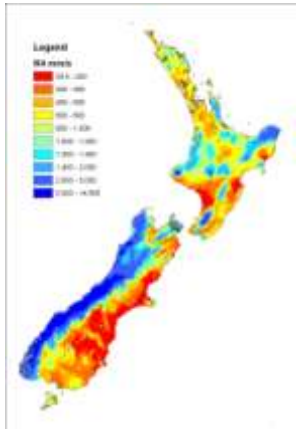
- They need ways to
  - find out what the researchers have done
  - get access to the "useful" results
- Web sites, training courses, meetings, informal groups (e.g., "Friends of Forest Hydrology")



# Practitioner's PUB Needs

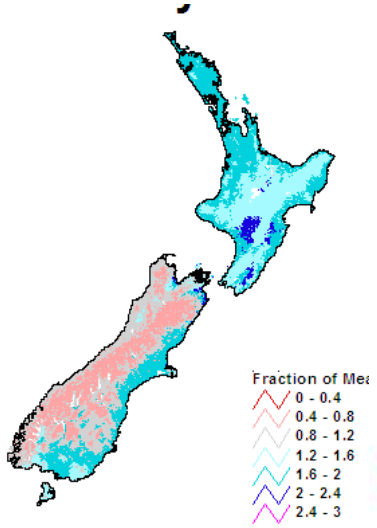
- EASY–ACCESS (via web) to basic data resources such as:
  - Climate maps (and estimated climate time series)
  - Catchment boundary delineation tools
  - Streamflow regionalisation products
  - Measured streamflow at regional sites
  - …
- Clear descriptions of how the products were created, their intended uses, and their limitations

Mean flow

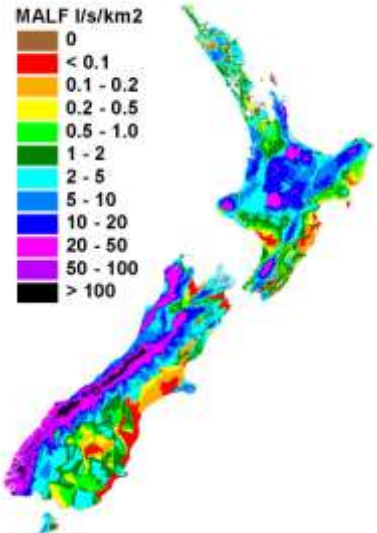


Snow Fraction

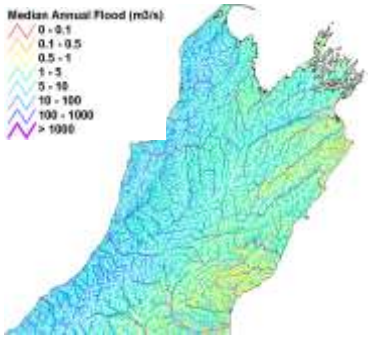
Flow Seasonality




Low Flow




Flood flow



# Hydrology Research Outreach

- Practitioners
  - Are a rich source of new research questions
  - Are keen to use new improved methods
  - BUT, time and $ constraints will not go away any time soon – slow process of “client” education
  - Researchers need to build a relationship with practitioners
    - Start by using (old) research to support the practitioners’ current needs, rather than with latest research model
    - Quantify predictive uncertainty (open communication on performance)
    - Researchers seek a pathway from what practitioners do now, to the ‘state of the art’
    - Gradually build up to more complex tools