# RMM-NTUA – Reservoir Management Model

Model description

Andreas Efstratiadis, Stefanos Kozanis

# Main modelling issues

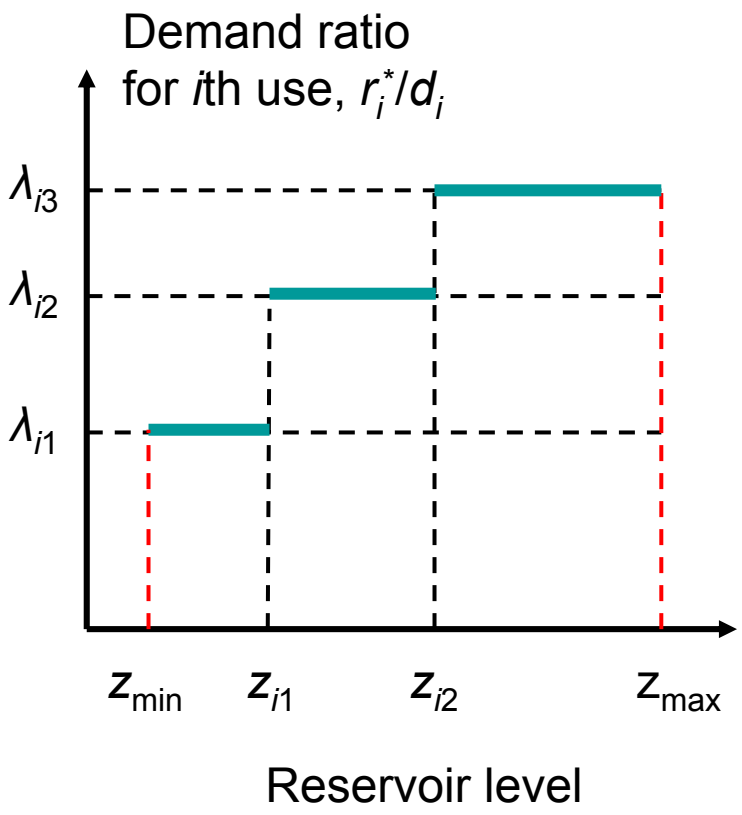
- Incorporating multiple water uses and assigning operation rules to each use.
- Taking into account all essential water balance components, including losses due to evaporation and leakage.
- Ensuring flexibility regarding time-scale (from daily to monthly).
- Providing a user-friendly interface to handle data.

# Reservoir simulation model: Input data

- Time step and time horizon of simulation;
- Level-storage and level-surface data (given as point series);
- Characteristic levels (minimum, maximum, initial);
- Upstream watershed area;
- Time series of precipitation and evaporation depths;
- Runoff time series;
- Leakage function coefficients (monthly);
- Water uses properties (priority order, demand time series, operation rules).

# Assigning operation rules

- Operation rules specify the desirable release, $r_i^*$, for the corresponding use $i$, as a function of the actual level, $z$.
- Desirable releases are expressed as ratios of the actual demand, $d_i$.
- For each use are assigned step functions, expressed as point series ($\lambda_{ij}$, $z_{ij}$), where $z_{min} \leq z_{ij} \leq z_{max}$ and $0 \leq \lambda_{ij} \leq 1$.
- There is no limit on the number of ($\lambda_{ij}$, $z_{ij}$) pairs.



# Overview of simulation (1)

- Inputs: Actual storage $s_t$, upstream runoff depth, $q_t$, precipitation depth, $p_t$, evaporation depth, $e_t$.
- Adjust inflow using the formula:

$$i_t = q_t\,(a - a_t) + p_t\,a_t - e_t\,a_t$$

  where $a_t$ is the actual surface and $a$ the basin area.
- Subtract losses due to leakage, estimated by:

$$l_t(z_t) = \alpha\,z_t^3 + \beta\,z_t^2 + \gamma\,z_t + \delta$$

  where $z_t$ is the actual level and $\alpha$, $\beta$, $\gamma$, $\delta$ constants, varying with month (because leakage may depend on the seasonal fluctuation of water table ).
- Actual water availability, before releases ($i = 0$), is given by:

$$s_{0t} = s_t + i_t - l_t$$

# Overview of simulation (2)

- Reservoir releases are implemented following the water use hierarchy (for $i = 1, \ldots, n$ uses).
- Assuming water use $i$, the corresponding desirable release is determined on the basis of the actual level and the actual demand, i.e. $r_{it}^{*} = \lambda_{ij}\, d_{it}$, where $\lambda_{ij} = f(z_t)$.
- Real release cannot exceed the actual useful storage, i.e.:

$$r_{it} = \min\left(r_{it}^{*},\ s_{i-1,t} - s_{\min}\right)$$

- Update water availability (= reservoir storage), i.e.:

$$s_{it} = s_{i-1,t} - r_{it}$$

- Recalculate reservoir level, as function of the new storage.
- When all uses are fulfilled, estimate spill by:

$$w_t = \max\left(0,\ s_{nt} - s_{\max}\right)$$